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Art. I.—*Account of the National Military School of the United States of America.*

[Communicated by the Author.]

The Military School at West Point is an institution of which the people of the United States are with reason proud. It is also one which promises, at no distant period, to exert a very considerable influence upon the character and habits of that nation. For this reason, and because it presents several features well worthy of notice, and even of imitation, we have thought that a succinct account of its actual situation and future prospects, together with a few remarks upon its excellencies and defects, will not be unacceptable to our readers.

This Military School is situated in the State of New York, about sixty miles from the city of that name, and on the western bank of the Hudson River. The parade ground comprises a space of several hundred acres, nearly level, elevated about two hundred feet above the river, whose banks are precipitous; this plain is enclosed by the river on two sides, while to the west and south it is bounded by steep rocky ridges, forming parts of mountains that rise to the height of from 1,200 to 1,500 feet. From the plain, a view presents itself towards the north-west, almost unrivalled in beauty and extent. The river is first seen, confined between rocky mountains, through two ridges of which it seems as if it had forced its way at some former period,

yet still presenting a channel of more than a thousand yards in breadth, navigable in every part for the largest ships; beyond this it spreads into a wide way, and bending towards the east is lost to the sight; the shore of this bay next appears, studded with populous villages, and rich with cultivation, over which are seen a succession of woody eminences and fertile vales, until the view is bounded by the straight outline of the Shawangeurk ridge, and the more distant, lofty, and picturesque summits of the Kaatskill mountains. In other directions, the prospect is less extended, but is still magnificent, presenting occasional glimpses of the river, and a rich amphitheatre of mountains clothed with forests. The artificial objects constantly moving upon the river are hardly less interesting than the natural scenery; they consist of steam-boats thickly crowded with passengers, and vessels of every variety, from the occasional Indiaman and whaler, to the smallest river-craft.

If, as is generally admitted, the youthful mind receives a character from surrounding objects, such a position as West Point is admirably suited in that respect to the purposes for which it is employed; and it besides possesses the advantages of fine water, pure air, and a most salubrious climate. But in addition to physical circumstances, there are also mental associations that cannot fail to have a powerful influence. West Point is distinguished in the annals of the American revolutionary war, as affording a final and insuperable barrier to the favourite plan of the British ministry, which was, by simultaneous movements from Canada, and New York, upon the line of the Hudson, to divide the eastern from the southern States. At West Point, Arnold commanded when his revolt had nearly furnished the means of overthrowing this barrier; and in the casemates of one of its fortresses the unfortunate André was confined in the brief and melancholy period that elapsed between his capture and trial. At West Point, too, Kosciusko, not less the champion of American than of Polish liberty, long resided, and his favourite resort is still shewn, hanging like a shelf of verdure from the precipice, midway between the plain and the river.

The public buildings are principally situated on the south side of the plain. They consist of a mess-house, and hotel for the reception of visiters; the academy, which contains the principal lecture and visitation rooms; and two large barracks for the lodgement of the cadets. On the western side, are the houses of the superintendants, professors, and officers of the institution. There is besides on the north, close to the bank of the river, a large barrack for the accommodation of a company of regular troops that is constantly on duty at West Point, and of the musicians and artificers.

The public edifices are plain buildings of rubble-stone, without any pretension to architectural embellishment, but solid and substantial; the dwelling-houses are chiefly of brick, and are convenient and comfortable: the barrack for the troops is of wood, and although entirely destitute of ornament, has more architectural beauty of form than any other building on the Point.

The establishment consists of two hundred and fifty cadets, entirely supported and educated at the expense of government. In the earlier stages of the school, before its advantages were appreciated, and before the system of education reached the state in which it now is, the number of applicants rarely amounted to more than the vacancies, and no rule was adopted in relation to the choice of candidates. Of late, however, the appointment of cadet has been eagerly sought for, and the principle has been followed, of dividing the warrants among the several states in the ratio of representation, and it is now contemplated to extend this principle, so that each congressional district shall always have a pupil at the academy. The cadets are divided into four classes, one of which graduates annually, and has its place supplied by new warrants. The course, therefore, occupies four years, and is divided and distributed in the following manner. During the first year the principal attention is directed to Mathematical studies, and to the acquisition of the French language. To obviate a difficulty too frequently experienced in other American institutions, where it becomes necessary to suit the course to a medium state of talent and industry, by which it happens that

boys of talent are but partially employed, while the dull and careless are left behind, it is adopted as a general rule at West Point, to divide each class into as many sections in each department as will, on the one hand, secure the utmost proficiency, and on the other, prevent any absolute failures, unless they arise from negligence and idleness. The lower class has four sections in mathematics, and five in the French language. The first mathematical section of this class passes through a course that comprises algebra, geometry, analytic plane and spherical trigonometry, and descriptive geometry: the studies of the second section are the same as those of the first, but differ a little in extent: in the third section, the same subjects are still studied, except that but a portion of the text-book in descriptive geometry is prescribed; while the fourth section proceeds no further than algebra and geometry.

The studies of the next class are still chiefly in the same branches, and it is divided in mathematics into three, in French into four sections. The first mathematical section studies surveying, descriptive geometry, conic sections, perspective, analytic geometry, and the *Calcul Différentiel et Intégral* in the treatise of Lacroix; the second, surveying, descriptive geometry, conic sections, perspective, analytic geometry, and the *Calcul* in the treatise of Bourhalot; the third, analytic plane and spherical geometry, surveying, descriptive geometry, perspective, and fluxions in the American edition of Hutton's Mathematical Course. In this year the cadets commence a course of drawing, which is confined, while they continue in this class, to the human figure.

The third year is devoted to natural philosophy, chemistry, and the drawing of landscape and topography. The philosophical department has three sections, and the chemical four.

The fourth year's course comprises engineering, mineralogy, geography, history and ethics, and military tactics. The class in Engineering has two sections.

Although military tactics are only taught theoretically during the last year, a considerable portion of time is spent daily in acquiring practically a knowledge of the duties of the soldier. With

this view, and for the preservation of discipline, a guard is regularly detailed, centinels posted, detachments made for police duties, a strict inspection held of clothing, arms, and equipments, and regular drills in the manœuvres of infantry and artillery performed, under the eye of the professor of tactics, who has the immediate military command of the cadets. The posts of non-commissioned officers are given as rewards for military merit, and the several appointments of command in battalion, are held in rotation by the cadets of the highest class. The discipline of the lecture and class-rooms is also strictly military; each section has its officer, who is bound to notice, and, if necessary, report every instance of irregularity, and who is responsible for the deportment and conduct of his squad. The professors and teachers are thus relieved from every care except that of instruction, and have, in consequence, situations highly enviable, when compared with similar ones in other American institutions, where much more labour, both of body and mind, is incurred in the preservation of good order, the punishment and reformation of offenders, than in actual instruction. The military school, indeed, presents a most interesting example of strict order and discipline; every duty, whether of the soldier or the student, is performed at its appointed time, without the least confusion, and every hour from *réveillé* to *tattoo* has its appropriate duty and employment.

It is in this respect that the real and paramount excellence of the Military Academy consists; every cadet, whatever be his proficiency as a student, insensibly acquires habits of regular application to business, of courteous and gentlemanly manners with equals, of submission to superiors, and of firm, yet condescending conduct to those in subordinate situations, that are of immense value to him throughout life; and no instance has ever occurred where a graduate has not fully realized the expectations that have been formed of him, when called to active service.

Such being the obvious and apparent results of an education at West Point, it may not be uninteresting to inquire into the means by which they are produced.

In addition to the division of the classes into sections, each

section is arranged in individual rank, according to the respective merit in study of the individuals that compose it; those who manifest the necessary improvement are advanced into higher sections; those who fall off, degraded to lower; and the incorrigibly idle dismissed the institution. In addition to this arrangement in the several departments of study, general merit-rolls of each class are formed, in which military acquirements, and correctness of deportment, have their full weight. These rolls are made up at the general examinations, which occur twice a year—once in the presence of the assembled instructors only, and once publicly, and before a board of visitors, named by the Secretary of War for the purpose. These rolls are not only submitted to the War-department, and printed, but the names of the four most distinguished cadets in each class are annually published in the army-list of the United States. Every cadet who passes through the four years' course, and receives his diploma, is entitled to a commission in the army, whether there be vacancies or not; and among the vacancies that may have occurred within the year, the most distinguished cadets have the right of choice, in the order of the general roll of merit.

For breaches of good order and discipline, for inattention to the duties of the soldier, the punishments are,—extra drills—additional police duties in the barracks, or externally—arrest in their rooms—confinement in the guard-house—in the light or dark prison,—and finally dismissal. The punishment of dismissal involves such consequences, as in most cases, to ensure entire submission: it not only deprives the delinquent of an education at the public expense, but is a bar almost insuperable to employment in the service of the government; for although there is no specific law on the subject, it has become a matter of understanding among the several departments, that no disgraced cadet shall, on any account, receive an appointment in the gift of the executive of the United States.

It is difficult to conceive any improvement upon this part of the system. It owes its perfection of principle and practice to the unwearied efforts of the present superintendant Lt.-Col. Thayer, of

the United States Corps of Engineers. Its success in application is also due, in a great measure, to the firmness, impartiality, and temper, with which he has discharged his difficult and important task; but, in this respect, he has received no small aid from the present accomplished instructor in military tactics, Major North.

The most important department of scientific instruction in the Military Academy, and that which is most successfully conducted, is the mathematical. As this forms the basis of the higher departments, and is chiefly depended upon at West Point, as an exercise for the formation and discipline of the youthful mind, the present superintendant has wisely directed his attention in an especial manner to the perfection of this department. Himself an able mathematician, and powerfully assisted in his first efforts by a very distinguished *élève* of the French Polytechnic School, he has elevated by a series of rapid and successful improvements this branch of education to a very great height, and has formed a set of teachers who are fully adequate to carry it on successfully. This state of perfection consists, perhaps, more in the very general and extensive diffusion of mathematical acquirements, than in the depth to which they are pursued, even by the most advanced pupils; the highest acquirements are limited to the elements of the integral and differential calculus, and even this is of recent introduction as a regular branch of study, while the calculus of variations is not at all studied. We state this, to do away a very general impression, that the opportunities for mathematical acquirement are greater at West Point than at any other institution in the United States; this is not the case: in Columbia College, New York, which we adduce in consequence of its proximity to West Point, the course is considerably more extended; but while, at West Point, a certain progress is made by all the pupils, and in the highest degree by many,—in other institutions, great acquirements, and even close and accurate knowledge, are limited to those who from taste and inclination devote themselves to mathematics. No person can enter into the second class at West Point, who is not well and thoroughly grounded in the elements of this science; he must either remain in the class below, or be dismissed the Institution,

If any defect can be noted in the manner of teaching the mathematics at West Point, it is that their practical use, and the importance of their application to innumerable purposes in life, are not sufficiently insisted upon; and thus the student occasionally toils, without any other reward than that of gratifying a generous emulation, or complying with the regulations of the Institution. But this defect is yearly lessening; it is, in truth, no bar to progress under this well-arranged system; and where the principles are well understood, the acquisition of the practical part, when it may in after-life become necessary, will be easy and obvious.

The mathematical course is entirely conducted upon the analytic method, a method that if it be at first less obvious to the student, is much the most conducive to rapid progress in the higher branches, and prepares the way for the study of the most extended application of the science. In this course it is, perhaps, to be regretted that the methods of the ancient geometers are not studied to the extent of at least the four first and the sixth book of *Euclid's Elements;* these may not furnish as good a basis of mathematical knowledge as the *Treatise of Lagrange*, but of all modes of disciplining the mind to habits of correct and clear thought, the logic of the ancient mathematicians is perhaps the best.

The French language is also extremely well taught at West Point; but the advances made in this study are not as uniformly good as in mathematical science. The reason of this does not exist in any defect in the system of the Academy, or in the method of instruction, but depends solely upon the state of previous preparation in which the cadets enter the military school. The requisites for admission are, that the candidate shall have reached the age of fourteen years, and be well grounded in the grammar of the English language, and arithmetic; to write a legible hand is also insisted upon. At the age of fourteen, it frequently happens that many of the candidates for admission have acquired, in addition, an acquaintance with the Latin language; a few, both with Latin and Greek; and it sometimes occurs that others have an accurate knowledge of French. From these causes, it arises

that an inequality is instantly manifested, which leads to more extended subdivision into sections in the department of the French language than in any other, and that while some of the cadets converse fluently in that language, and write it with purity, others attain, with difficulty, the power of reading it with ease. In the mathematical studies, on the other hand, the cadets when admitted, are much more upon a footing, and hence the progress is more uniform, depending wholly upon the degree of industry and talent.

The Chaplain of the institution is charged with instructing the higher class in the departments of geography, history, and ethics. In the earlier history of the Military School, when the cadets were an integral part of the Engineer corps, and the institution intended as a school of practice in that branch of military learning, this might have been sufficient for the revision of previous studies; but at the age, and under the circumstances that the cadets are at present admitted, it is of little value, and the proficiency of the student is almost entirely due to his previous knowledge. This is the most faulty part of the system of instruction; for it sometimes happens that individuals are distinguished for their mathematical skill, who would find it difficult to express themselves with precision upon paper. This course should be extended and made collateral, during, at least, three of the years spent at West Point, and ought to be made to comprise instruction in the *belles lettres*, and in English composition. To obviate, in some measure, the defects in this respect, a society for mutual improvement exists among the cadets, and has been productive of valuable consequences when previous attainments existed, but it is, of course, inefficient in its influence upon those who bring no preliminary knowledge.

Although an extension of the time devoted to this department would be productive of much good, yet the only radical cure for the defects of instruction we have pointed out, is to be found in raising the requisites for admission. There is no other mode in which a uniform preparation for these studies, and for that of the French language, can be attained, except by insisting upon an ac-

quaintance with the Latin language, so far, for example, as to be able to construe with facility the Æneid of Virgil, and the Orations of Cicero, before a cadet is admitted into the lower class. We are satisfied that this simple step would eventually add more to the reputation of the Institution than any that could with equal convenience be adopted.

Chemistry has only recently become an important part of the instruction given to the cadets. Nor is there, even now, an endowed professorship; the duties are exercised provisionally by the surgeon of the post, but it is so arranged, by giving him an assistant, that he may devote his whole time to them. With all these difficulties of recent introduction, and imperfect organization, the present surgeon, Dr. Torrey, has succeeded in establishing a most complete and perfect course of instruction. Such, indeed, is the zeal, vigour, and ability with which he has executed his task, that he has given it a marked preponderance over a co-ordinate branch far more extensive and important in reality. To this branch we shall next proceed.

The department of natural philosophy includes the subdivisions of the mechanics of solid and fluid bodies, optics, magnetism, and astronomy. The first section is instructed by the aid of *Gregory's Mechanics* as a text-book, a work, if not faultless, yet sufficiently adapted to the purpose; but the second section, and even the first in the physical and astronomical part, has no other text-book than the very imperfect and deficient work of Enfield; a work not only incorrect and defective in its method, but far behind the present state of science. It thus happens that even the subjects of instruction are far inferior in extent to the course taught at Harvard University by Professor Farrar, and still more so to that taught in the neighbouring institution, Columbia College. But if behind in extent of subject, it is still more defective for want of experimental illustration. A prominent reason for this last defect is to be found in the imperfect state of the philosophical apparatus; but even that which the Institution does possess, is but little used. This is most evident in the case of astronomy; a complaint is constantly made by the Professors of the want of instru-

ments, and successive boards of visitors have recommended large appropriations for their purchase, and for the erection of an observatory; and yet it is notorious that a clock, and two fine transits by Troughton, a reflecting circle by the same artist, and several excellent sextants, remain unemployed, although kept in a building almost as well suited for the purposes of observation, as if it had been expressly constructed with that view.

Time, probably, has not yet permitted the superintendant to introduce the same improvements into the course of natural philosophy that he has into the departments of mathematics, and the French language, and into the general discipline of the Academy. He wisely applied his first efforts to those fundamental pursuits; the one so important as the basis of all scientific military acquirement; the other essential as furnishing a key to the most valuable authors: nor, indeed, could the department of natural philosophy receive its final completion until the mathematical course was perfected, and the fluxional calculus universally studied and understood. He has also had many obstacles to contend with, and various circumstances have interposed to impede his efforts in that direction. Neither has it been as readily practicable to form teachers in that as in the other courses, from the graduates of the Institution. We may, therefore, still hope, that as the works of Lacroix and Legendre have been introduced by him into the mathematical department, the mechanics of Poisson, the physics of Biot, and the astronomy of Delambre, will, before long, furnish the subjects of lecture in the philosophical. This will be the more important, as only then will the valuable objects of the mathematical studies, in their most important applications, be obvious to the learner.

The imperfections of this department are, however, rather absolute than relative, for it is still superior to any similar course in other American institutions, with the exception of the two that have been mentioned; these alone, of the colleges to the east of the Hudson, have discarded Enfield's work as a text-book, and one of them has not done it before the present year. It must also be observed that the same result of discipline is found here as

in every other branch of the academic instruction; *whatever is taught, is taught thoroughly.*

The course of engineering is complete, and admirably conducted, both in its military and civil branch. Nothing, perhaps, remains to be desired, except a complete set of models for its illustration. And here we might suggest, that instead of waiting for the slow aid of legislative appropriations for the purchase of such a collection, it might be made by the artificers on duty at West Point, under the superintendence of the professor.

The officers engaged in directing the studies of the several classes in the above departments are—the superintendant, the military instructor, a professor of natural philosophy, a professor of engineering, and a professor of mathematics ; the surgeon, who acts as professor of chemistry ; and the chaplain, who acts as professor of ethics ; two teachers of the French language, one teacher of drawing, three lieutenants in the army, and ten cadets, who act as assistant professors, making in all an academic staff, twenty-two in number. In the last report of the board of visitors, it is recommended to increase this part of the establishment to the number of twenty-six. It is probable that no institution in the world exhibits a list of teachers bearing so great a proportion to the number of pupils ; and as the undivided attention of each of them is devoted to his section, this great proportion of teachers is attended with invaluable consequences.

The library of the Military Academy is of great value. The mathematical portion may be considered as complete, having, in addition to every valuable work of late date in the French and English languages, lately received an accession of a full series of the more ancient authors, from the time of the Greek geometers to the commencement of the French revolution. The collection of maps, both topographical and general, is very extensive, and of the best description. The collection of works on subjects strictly military is also extensive; and, as relates to French authors, requires no addition. There are also a few valuable works, but by no means an extensive list, on general literature and science ; and the whole is annually receiving important

additions from a small contingent fund, disposable at the pleasure of the superintendant. If, then, we have been compelled to notice a few defects in its details, sufficient still remains worthy of the highest praise, to enable us to say, without any hesitation, that there probably exists no seminary of education in the world as perfect in its organization and discipline, or more generally effective in its course of instruction.

It is the more gratifying to express this high satisfaction, when its present state is contrasted with that in which it passed into the hands of Colonel Thayer, as superintendant. He has raised it, almost entirely by his own exertions, in the short space of seven years, from a comparatively low ebb to the state in which we have described it.

We have already intimated that every graduate of the institution is entitled, of course, to a commission in the army; and that the more distinguished pupils have the right of choice among the vacant commissions. The engineer service generally receives the preference, and next the artillery, and topographical corps. Not only are they entitled to commissions, but at present none are granted except to them; and it is proposed, not only for the sake of the public service, but as an additional excitement to exertion, to reorganize and extend the last-named corps, and to create a body of civil engineers in the service of the government, to be formed exclusively from the Military School. We do not, however, conceive that this conclusion is just: it is a sufficient advantage to enjoy the facilities of education at the public expense, and the certainty of employment, without closing the door against those who may prepare themselves for a similar course of life at their own expense. This principle has certainly hitherto aided in establishing the character of the school, but the time may come when it will be injurious, in limiting the progress of the candidates by a standard created among themselves, and that may not be commensurate with the general progress of education. So, also, the restriction of the appointment of professors and teachers, in the existing departments, to members of the academy, which has hitherto been productive of much good, must finally be

injurious, by removing a powerful stimulus to exertion. It would be quite sufficient, in both cases, after opening the offices to general competition, to give a preference, all other things being equal, to those educated at the Military School*.

* The advantages which the government of the United States derives from the services of the officers who have been thus educated, cannot be better illustrated than by the following extract from Mr. Munroe's message to Congress, in the last year of his Presidency, December, 1824:—

"Under the act of the 30th of April, 1824, authorizing the President to cause a survey to be made, with the necessary plans and estimates, of such roads and canals as he might deem of national importance in a commercial or military point of view, or for the transportation of the mail, a board has been instituted, consisting of two distinguished officers of the corps of engineers, and a distinguished civil engineer, with assistants, who have been actively employed in carrying into effect the objects of the act. They have carefully examined between the Potomac and the Ohio rivers; between the latter and Lake Erie; between the Allegany and the Susquehana; and the routes between the Delaware and the Yaritan, Barnstaple, and Buzzard's Bay; and between Boston Harbour and Nawagause Bay. Such portion of the corps of topographical engineers as could be spared from the survey of the coast, has been employed in surveying the very important route between the Potomac and the Ohio. It is contemplated to commence early in the next season the execution of the other branch of the act; that which relates to roads, and with the survey of a route from this city (Washington) through the southern states to New Orleans, the importance of which cannot be too highly estimated. All the officers, of both the corps of engineers, who could be spared from other services, have been employed in exploring and surveying the routes for canals. To digest a plan for both objects, for the great purpose specified, will require a thorough knowledge of every part of our Union, and of the relation of each part to the others, and of all to the seat of the general government. For such a digest, it will be necessary that the information be full, minute, and precise. With a view to these important objects, I submit to the consideration of Congress the propriety of enlarging both the corps of engineers, the military and topographical. It need scarcely be remarked, that the more extensively these corps are engaged in the improvement of their country, in the execution of the powers of Congress, and in aid of the states in such improvements as lie beyond that limit, when such aid is desired, the happier the effect will be, in various views of which the subject is susceptible. By profiting of their science, the works will be always well executed; and by giving to the officers such employment, our Union will derive all the advantage in peace, as well as in war, which their talents and services can afford. In this mode, also, the military will be incorporated with the civil, and unfounded and injurious distinctions and prejudices, of every kind, be done away. To the corps themselves this service cannot fail to be equally useful, since by the knowledge they will thus acquire, they will be eminently better qualified, in the event of war, for the great purposes for which they were instituted

This institution, supported and endowed by the general government, is a most prominent object of public attention. Furnishing the executive with a powerful patronage, and supplying well-instructed and capable officers, it has been a favourite of every successive administration. It has hence become, in many instances, the mark and rallying-point of opposition; and has, on more than one occasion, been exposed to the danger of destruction by a refusal of the annual appropriation. That policy, however, which strikes at an object of general and acknowledged utility, because its destruction may weaken an opposing party, is most mistaken; happily it has lately received such a defeat as, it may be hoped, will prevent its being again brought forward, at least in the form of an attack upon the Institution. Its friends may therefore indulge themselves in the hope, that the reputation and usefulness of the academy will be every year extended; and that it will finally conduce as much to the prosperity, as to the scientific reputation of the United States.

Art. II.—*Further Remarks on the Naturalization of Fishes, by* J. Mac Culloch, M.D., F.R.S.

[In a letter to the Editor.]

Dear Sir,

You will probably not object to my communicating to you, from time to time, any new matter or observations with respect to this interesting subject, which may chance to come to light, whether the result of my own experience or of that of others. If it was rather from the hopes of calling the public attention to this subject, and, in particular, the attention of those who had the power of making experiments, than from any other motives, that I communicated, originally, the scattered and imperfect facts contained in the two former papers, there will not be less use in noting, as they occur, any new facts which may serve to keep the subject alive in the public mind. A periodical journal is, from its very nature, transitory in its effects; and when any subject

which it includes chances not to meet the public feelings or pursuits, when it chances to be a new fact unconnected with our previous knowledge, its general fate is, to be consigned to speedy oblivion. To keep it alive is, therefore, of use; if, at least, it is one of those facts which may, by extension, be converted to purposes of utility. What I have now to add is indeed so little, that on no other view, perhaps, would it be worth communicating. But in this view every thing will be of use; nor shall I require any apology for the quotation I have made from a paper already printed, since it will be advantageous to the public that the journal which contains the greatest mass of evidence, and which undertook first to examine the subject, should also contain the whole evidence that can be accumulated. If I were inclined to add much to these preliminary remarks, it would be my regret that the subject in general should have met with, not merely neglect, but opposition; as if the infliction of an evil on society, instead of the communication of a benefit, had been meditated. As far as my own personal efforts have gone, and as far also as my own knowledge extends, I have not found a single individual who has been willing to make, or rather to repeat, the trials, even where the readiest and amplest opportunities were present. And this, not only as to fishes, not yet made the subject of experiment, but even as to those of which the success has been demonstrated. On the contrary, the proposition has invariably been met by counter arguments, *priori* arguments; just as if there had been no evidence existing, and as if attempts at the improvement of human life were disgraceful or noxious. Experiment used to be considered the road to knowledge: evidence has commonly been considered a thing to be examined, and, if true, to be admitted. It is probable that opinions on this subject have changed since the days of Bacon; since, at least as far as my acquaintance extends, Mr. Arnold, my original friend and experimenter on this subject, is the only man who has not rejected what has been proposed, and who has gone steadily on in what used to be considered the path of a true philosopher. Doubtless an objector may be allowed to question the personal veracity of a

witness: and he may be allowed to suspect the testimony of a projector, who has a private interest in his projects: but those reasons wanting, I know of no solution but that one which I proposed in another place; namely, that pride which, imagining that it has attained all knowledge, is too wise to learn; coupled, perhaps, with the hatred of a discovery which belongs to a therefore hated discoverer. I have no objection, however, to a better explanation if any one will undertake to furnish it. In this case, the discovery does not fairly admit of jealousy, since the guilty discoverer is Nature herself.

The mention of Bacon's name reminds me of what I had originally forgotten, namely, that he had himself speculated on this very project. It will be found in his Eighth Century of Natural History; but the paragraph contains no evidence, and not much to the purpose in any shape. He remarks that fish used to the salt water "do nevertheless delight much more in fresh;" quoting the salmon and the smelt. "I doubt," he says, "that there hath not been sufficient experiment made of putting sea-fish into fresh-water ponds and pools. It is a thing of great use and pleasure; for so you may have them new at some good distance from the sea; and, besides, it may be that the fish will eat the pleasanter, and may fall to breed." Such was the prophetic eye of him who did not reject experiment, even though it had never been tried. Why is it rejected now? Not because there are no philosophers; but because men who possess money and ponds have no philosophy, and men who possess philosophy have neither ponds nor money.

Thus far, is opinion only: but the two following facts are valuable, because they are natural experiments, and because, being related as mere matters of fact, by persons without any interest in them, and without producing any inference, or being referred to any system, they belong to the purest kind of evidence. They have occurred in the course of my casual reading, since the last communication on this subject.

In the Isle of Osero on the coast of Dalmatia, there is a fresh-water lake inhabited by sea-fish; the authority being that of a

well-known French artist whose picturesque work on this coast is familiar, though his name has at this moment escaped me. It is somewhat unfortunate that this had not been a more specific object of inquiry, as the names of the fishes are not given; and on searching Fortis for this purpose, I have not discovered what I wished.

The other case is the reverse of this; and though the authority in Phillips's *Collection of Travels* may not be very highly esteemed, there is no reason to doubt the simple assertion of any traveller respecting a well-known matter of fact, and a practice familiar to the natives; particularly when narrated among other casual things, and without conclusions. It is a salt lake at the Cape de Verde, which is inhabited promiscuously by marine fish and by those of the neighbouring rivers. Here also, unfortunately, no names are given; so that this case can be added only in support of the general principle.

The last fact to be here placed, is the one which I proposed to quote for the purpose of keeping the evidence as much as possible together. It is the discovery of the Cockle, or Cardium edule of Linnæus, in a living state, under a peat moss, near Greta bridge, about two miles from the river Tees, and forty miles from the sea. The fact is recorded by Mr. Stark, but belongs to Mr. Witham; and confirming what I had occasion to say formerly respecting other shell fishes, will also prove that, if cockles were worth cultivating, they might be bred anywhere in land, where sand and fresh water exist.

I wish now that those who know Naples, would determine whether the common oyster is really there a native of fresh-water lakes, and fished for common use. So it has positively been asserted to me, by more than one traveller; whereas on examining others, it has been as positively contradicted. Thus difficult is it to extract truth from those who are not in the habit of accurate observation. Be it true, it might possibly tempt those who prefer oysters to opposition, to cultivate them in their lakes; be it true or false, as to Naples, I have little doubt that this is practicable.

I know not, if I formerly mentioned that the Pleuronectes Limanda was found in the Loire; if not, it will be one to add to the lists formerly given.

Art. III.—*On Pure Caoutchouc, and the Substances by which it is accompanied in the State of Sap, or Juice.* By M. Faraday, F.R.S., Cor. Mem. Inst. of France.

[Communicated by the Author.]

I have had an opportunity latterly, through the kindness of Mr. Thomas Hancock, of examining the chemical properties of caoutchouc in its pure form, as well as of ascertaining the nature and proportions of the other substances with which it is mixed, when it exudes as sap, or juice, from the tree. At present much importance attaches to this substance, in consequence of its many peculiar and excellent qualities, and its increasing applications to useful purposes. I have thought, therefore, that a correct account of its chemical nature would possess some interest.

The extensive uses, both domestic and scientific, to which Mr. Hancock has applied common caoutchouc, in consequence of his peculiar mode of liquefying it, are well known. Hence he was fully alive to the importance of its applications, when in its original state of division. When he gave me the substance, he communicated many of his observations upon it, which, with others of my own, form the present paper.

The fluid, I understood, had been obtained from the southern part of Mexico, and was very nearly in the state in which it came from the tree; it had been altered simply by the formation of a slight film of solid caoutchouc on the surface of the cork which closed the bottle. The caoutchouc thus removed was not a 500th part of the whole. The fluid was a pale-yellow, thick, creamy-looking substance, of uniform consistency. It had a disagreeable acescent odour, something resembling that of putrescent milk; its specific gravity was 1011.74. When exposed to the air in

thin films it soon dried, losing weight, and leaving caoutchouc of the usual appearance and colour, and very tough and elastic: 202.4 grains of the liquid dried in a Wedgewood basin, at 100° Fahr., became, in a few days, 94.4 grains, and the solid piece formed being then removed from the capsule, and exposed on all sides to the air until quite dry, became 91 grains: hence 100 parts of sap left nearly 45 of solid matter.

Heat caused immediate coagulation of the sap, the caoutchouc separating in the solid form, and leaving an aqueous solution of the other substances existing with it in its first state.

Alcohol poured into the sap in sufficient quantity, caused a coagulum and a precipitate, both of which were caoutchouc of considerable purity. The alcohol retained in solution the extraneous matters, which, possessing peculiar properties, will be hereafter described.

Solution of alkali added to the sap evolved a very fetid odour, but did not appear to exert any particular action on the caoutchouc.

The sap, left to itself for several days, gradually separated into two parts, the opaque portion contracted upwards, leaving beneath a deep-brown, but transparent, solution, evidently containing substances very different in their nature from caoutchouc itself, and which, considering the specific gravity of the sap and of pure caoutchouc (the latter being lighter than water), were probably present in considerable quantity.

It was found that, by mixing the sap with water, no other change took place than mere dilution. The mixture was uniform, and had all the properties of a weak or thin sap. Heat, evaporation, acids, and alkali, produced the same effects, generally, as before.

When the diluted sap was suffered to remain at rest, a separation soon took place, similar to that which occurred with the native juice, but to a greater extent; a creamy portion rose to the top, whilst a clear aqueous solution remained beneath. Hence it was found easy to wash the caoutchouc, and remove from it other principles which had been generally involved in it to a greater or smaller extent during its coagulation. For this purpose

a portion of the sap was mixed with about four volumes of water, and the mixture put into a funnel, stopped below by a cork; in the course of eighteen or twenty-four hours, when the caoutchouc had risen to the top, and occupied about its original volume, the aperture at the bottom of the funnel was opened, and the solution drawn off; more water was then added to, and mixed with, the caoutchouc, and the operation repeated, and this was done four or five times, until the water came away nearly pure. During the latter washings, the caoutchouc required a longer time to rise to the surface, in consequence of the decreasing specific gravity of the solution in which it was suspended. This was obviated at times, according to the experiments for which the caoutchouc was required, by performing the first washings with solutions of common salt, muriatic acid, &c., and ultimately finishing with pure water.

In this way the caoutchouc was purified, without any alteration of its original state. It now appeared in its state of mixture with water, perfectly white: portions of it left for a twelvemonth over water, underwent no change in that time, except coagulation and a slight film upon the surface; the rest was as miscible with the water as at first, and, when coagulated, equally elastic. Tue sap, or the washed caoutchouc, is much more easily preserved in the diluted than in the concentrated state.

It produced no particular appearance with the solutions of iron, or other metals.

When evaporated, either on paper, or in a capsule, or otherwise, the caoutchouc was left in its elastic state, and perfectly unaltered, except with respect to purity. When put on to absorbent surfaces, as bibulous paper, chalk, or plaster of Paris, the water was rapidly abstracted, and the caoutchouc almost immediately united into a mass, retaining the form of the thing on which it was cast. In this way Mr. Hancock has made beautiful medallions with the sap. Poured on to a filter, the water passes through, and the caoutchouc coagulates.

When aggregated in any of these ways, the caoutchouc appears at first as a soft white solid, almost like curd, which by pressure exudes much water, contracts, becomes more compact, has ac-

quired elasticity, but is still soft, white, and opaque. It also attains this state, without pressure, if time be permitted for the water to evaporate. The opacity belonging to it is not an essential property of the body, but due to water enclosed within its mass ; further exposure to air allows of the gradual dissipation of this water, and then the caoutchouc appears in its pure and dry state, as a perfectly transparent, colourless, and elastic body, except it be in thick masses, when a trace of colour is perceived. The change from first to last is best seen by pouring enough of the pure mixture into a Wedgewood or glass basin, to form ultimately a plate of $\frac{1}{10}$ or $\frac{1}{12}$ of an inch in thickness, and leaving it exposed to air at common temperatures undisturbed.

No appearance of texture can be observed in the pure transparent caoutchouc ; it resembles exactly a piece of clear strong jelly. All the phenomena dependant upon its elasticity, which are known to belong to common caoutchouc, are well exhibited by it. When very much extended, it assumes a beautiful pearly, or fibrous appearance, probably belonging to the effects which Dr. Brewster has observed elastic bodies to produce, when in a state of tension, upon light. When it has been extended and doubled several times, until further extension in the same direction is difficult, it is found to possess very great strength. Its specific gravity is 0.925, and no reduplication and pressure of it in a Bramah's press was found permanently to alter it. It is evidently pervious to water in a slight degree, or otherwise the interior of a piece of caoutchouc coagulated from the sap, would always remain opaque. It is equally evident that water passes but very slowly, from the time it takes to evaporate that which lies in the middle of a thin cake. It is a non-conductor of electricity.

The pure caoutchouc has a very adhesive surface, which it retains after many months' exposure to air. Its fresh cut surfaces pressed together also adhere with a force equal to that of any other part of the piece.

A strip of it boiled in solution of potash, so strong as to be solid when cold, was not at all affected by it, except that its surface assumed a pearly or tendinous appearance ; no swelling or softening, above what would have been produced by water, occurred.

The combustibility of caoutchouc is very well known. When the pure substance is heated in a tube, it is resolved into substances more or less volatile, with the deposition of only a small trace of charcoal; at a higher temperature it is resolved into charcoal and compounds of carbon and hydrogen; it yields no ammonia by destructive distillation, nor any compounds of oxygen, and my experiments agree with those of Dr. Ure, in indicating carbon and hydrogen as its only elements. I have not, however, been able to verify his proportions, which are 90 carbon, 9.11 hydrogen, or by theory nearly 3 proportionals of carbon to 2 of hydrogen, and have never obtained quite so much as 7 carbon to 1 hydrogen by weight. The mean of my experiments, gives,

Carbon .	6.812	or	8 proportionals nearly
Hydrogen	1.000		7.

No means which have yet been discovered seem competent, when the caoutchouc has once been aggregated, to restore it to its pristine state. Previous to its aggregation it may be either scented or coloured. A solution of camphor in alcohol was added to water, so as to precipitate the camphor in a flocculent state; a little of this was added to some of the pure caoutchouc in water, well agitated, and then coagulation caused by heat or absorption; the caoutchouc obtained was highly odorous.

In the trials made to give it colour, the body colours were found to answer best—indigo, cinnabar, chrome-yellow, carmine, lake, &c., were rubbed very fine with water; then mixed well with the pure caoutchouc, in a somewhat diluted state, and coagulation induced either upon an absorbent surface or otherwise. Perfectly-coloured specimens were thus obtained.

The liquid obtained either by letting the sap stand for some time, or by the first and second washing, was of a brown colour, bitter, acid to litmus, in consequence of the presence of acetic acid, due apparently to spontaneous changes in the substances present. It was difficult to filter. Being boiled, acid vapours rose, a precipitate fell to the bottom, and now the solution (*a*) became clear, either by standing or filtration, and could be separated from the solid matter.

The precipitate or substance thus obtained was dark brown, glossy, and brittle, much heavier than water, not soluble in alcohol, ether, water, essential or fixed oils. Weak solution of alkali dissolves it, forming a deep-brown solution, precipitable by dilute muriatic acid. It burns upon platina-foil, like animal matter, with flame, leaving a bulky charcoal. When heated in a tube, it chars, yielding much ammonia. It resembles albumen more than any other substance, and is the source of the nitrogen or ammonia obtained by the distillation of common caoutchouc.

The brown aqueous solution (*a*) became frothy on agitation; alkali rendered it of a deep-yellow colour, and produced a putrescent odour similar to that evolved by alkali, or quick lime, from white of egg or blood. It was remarkably distinguished by the deep-green colour it produced with per salts of iron, especially when a little alkali was present, and the dense yellow precipitates it formed with muriate of zinc and nitrate of lead; indeed, precipitates were produced in solutions of most of the metals by it. The colour produced with iron does not seem to be a precipitate.

With the hope of obtaining something peculiar from this solution, a quantity of it was precipitated by nitrite of lead; a colourless solution and a yellowish-green precipitate were obtained. The latter, being well washed, was next diffused through water, and sulphuretted hydrogen passed through it; by filtration a deep brown solid was obtained, and a yellowish solution. The precipitate when washed and dried was brittle and hard; on platina-foil it at first burnt with flame, swelling much, and giving out odour of ammonia like animal matter; after that sulphurous acid burnt off, and ultimately lead and oxide of lead remained; hence it was a combination of sulphuret of lead, and a highly azoted substance. Heated in a tube, it gave out much ammonia; digested in alcohol, scarcely a trace of matter was removed.

The sulphuretted hydrogen solution being boiled and evaporated, left a yellow varnish-like substance, not deliquescent, soluble in water, acid to taste and to litmus, the acid not being sulphuric: it rendered per-sulphate of iron green, precipitated nitrate of lead, and gave no ammonia by heat.

The concentrated solution (*a*) acted upon by alcohol, had an insoluble matter thrown down, which being separated and well washed with alcohol, was afterwards treated with water, a deep-brown aqueous solution (*b*) was obtained, and a small insoluble portion left; this was almost black when dried, tasteless, brittle, burning with difficulty, and when heated in tube (*a*) giving much ammonia.

The solution (*b*) was almost tasteless, and when dried left a green, shining, brittle substance, resoluble in water, and of course precipitable by alcohol. It colours solution of per-sulphate of iron green; but if its strong aqueous solution be treated with muriatic acid, a reddish-brown precipitate is formed, which, when separated, dissolves in water, does not colour per salts of iron, and when evaporated yields a pulverulent substance, burning, but not with facility, and producing a little ammonia when heated in a tube.

The alcoholic solution from which these matters had been separated contained the particular principle which colours per salts of iron green. When evaporated it left a brown, brittle, transparent substance, becoming soft by exposure to moist air. It is very bitter, soluble in water, &c., slightly acid. When heated on platina-foil it does not burn easily, but runs out into a bulky charcoal, much like animal matter; at the same time it does not yield ammonia when heated in a tube *per se*, though the smell is very animal.

Ether warmed with it dissolved a small portion of matter, and the solution, upon evaporation, left globules, which, in all their characters, corresponded with wax; its quantity was but mall.

Nine hundred and eighty-one grains of the original sap were washed in water several times. The washed caoutchouc, being coagulated by heat and perfectly dried, weighed 311 grains. The aqueous solutions, upon being boiled, yielded sufficient of the heavy precipitate to equal, when dried, 18.6 grains. The clear solution was now evaporated to dryness and digested in alcohol, 28.5 grains of insoluble matter were left, and the solution, upon

evaporation, afforded 70 grains of dry matter. Hence the following are the contents nearly of 1000 parts of the original sap.

Caoutchouc	317.0
Albuminous precipitate	19.0
Peculiar bitter colouring matter, a highly azotated substance . . . . . . } Wax	71.3
Substance soluble in water not in alcohol . .	29.0
Water, acid, &c.	563.7
	1000.

Thinking it probable that whilst in its natural state of division the caoutchouc would combine more intimately or readily with fixed and volatile oils than when aggregated, as it generally is in commerce, an experiment or two were made in consequence. A portion of well washed milky caoutchouc being added to olive oil, and the two beaten well together, a singularly adhesive stringy substance was produced, which, holding the water diffused through it, assumed a very pearly aspect, stiffened, and was almost solid; upon being heated so as to drive off the water, it became oily, fluid, and clear, and was then a solution of caoutchouc in the fixed oil. On adding water and stirring considerably, it again became adhesive as before. Thus introduced, caoutchouc would, probably, be a useful element in varnishes.

Oil of turpentine being added to a mixture of one volume of sap and one volume of water, and well agitated with it, was found to be only imperfectly miscible; after standing twenty-four hours, three portions were formed: the lower, the usual aqueous solution; the upper, oil of turpentine, holding a little caoutchouc in solution; the intervening part a clot or tenacious mass, soft and adhesive, like bird-lime, consisting of caoutchouc, with some oil of turpentine. It was very difficult to dry, and always remained adhesive at the surface; but experiments of this kind were not pursued, for want, at that time, of further quantities of the original sap.

Such is a general view of the nature of the sap from which the substance is obtained, and of the substance itself. I have not

endeavoured to give an accurate account of the properties or quantities of the other substances present, because there is reason to believe that both vary in different specimens, probably according to the age of the tree, the time of the year, or the manner in which the sap is drawn; nor have I dwelt upon the inaccuracies of former accounts, inasmuch as they are evidently referable to the impurity of the substance examined.

Those who wish to look to former accounts of the chemical or physical qualities of this remarkable substance, will, perhaps, find the following references useful:—

1751. De la Condamine on an Elastic Resin, newly discovered at Cayenne, by M. Fresneau; and on the Use of various Milky Saps from Trees of Guiane or France Equinoctiale.—*Mém. de l'Acad. Royale*, 1751, pp. 17, 319.

1763. MM. Herissant and Macquer on Solution of Caoutchouc.—*Mém. de l'Académie*, 1763, p. 49.

1768. Macquer, Memoir on the Means of dissolving the Resin Caoutchouc, known by the name Elastic Resin of Cayenne, and making it appear with all its properties.—*Mém. de l'Académie*, 1768, pp. 58, 208.

1781. Berniard, Memoir on Caoutchouc, known by the name of Elastic Gum.—*Journ. de Physique*, xvii. 265.

1790. Fourcroy on the Sap furnishing Elastic Gum.—*Ann. de Chim.* xi. 225; again, *Connaissances Chimiques*, viii. 36.

1791. Grossart on the Means of making Instruments of Gum Elastic, with the Bottles obtained from Brazil.—*Ann. de Chim.* xi. 143.

1791. Fabbroni on Solution of Caoutchouc in repeatedly-rectified Petroleum.—*Ann. de Chim.* xi. 195., xii. 156.

Pelletier on Solution of Elastic Gum in Sulphuric Ether.—*Mém. de l'Institut*, i. 56.

1801. Howison on the Elastic Gum Vine of Prince of Wales's Island, and of Experiments made on the Milky Juice which it produces, with Hints respecting the useful Purposes to which it may be applied.—*Asiatic Researches*, v. 157.

1801. Roxburg, Dr.; Botanical Description of Urceola Elastica, or Caoutchouc Vine, of Sumatra and Pulo-Penang, with an Account of the Properties of its inspissated Juice, compared with those of the American Caoutchouc.—*Asiatic Researches*, v. 167.

1803. Gough; Description of a Property of Caoutchouc or Indian Rubber, with Reflections on the Cause of the Elasticity of this Substance.—*Manchester Memoirs*, N. S. i. 288.

1805. Simple Method of making Tubes of Elastic Gum Caoutchouc, avoiding the expense of Ether.—*Phil Mag.* xxii. 340.

1807. Murray's Chemistry, iv. 177, contains a compendium of what was then known respecting this substance.

Royal Institution, January, 1826.

Art. IV. *An Examination of the Differences in Chemical Composition between Cotton-Wool, Cotton-Cloth, and Turkey-red Calicoes. By* Andrew Ure, M.D., F.R.S., *&c.*

James Thomson, Esq., of Clitheroe, F.R.S., distinguished for the skilful application of chemical science to the art of calico-printing, obtained in the years 1813 and 1815, two patents for a method of discharging the Turkey-red colour; and for introducing, at the same time, into the discharged portions of the cloth, certain mordants. The first process consists in applying to the dyed cloth, by the block, copperplate or cylinder, tartaric acid thickened with gum; and after drying the cloth, passing it through a saturated solution of chloride of lime (bleaching salt) heated to about 100° F. When the pattern requires white figures, mere washing with cold water completes the process; but if the figures on the red ground are to be coloured, then the metallic basis of the particular colour is introduced in a saline form into the solution of the tartaric acid. Thus, for example, when yellow figures are wished for, nitrate of lead is dissolved in the solution of tartaric acid, and the mixture being thickened as usual, is applied by the block, &c., to the surface of the cloth. When the piece of goods is passed through the discharging bath, the red colour disappears, in consequence of the extrication and action of chlorine at the tartaric acid impressions, but the nitrate of lead remains. The cloth being washed in cold water, is next passed through a solution of bichromate of potash, which converts the white figures into a brilliant yellow colour.

The essential mordants of the Turkey-red dye, seemed to be oil and alumina. The cotton cloth, after a tedious repetition of oil, soda, and gall baths, is impregnated either in whole or in part, with a solution of an aluminous salt (usually alum). If the aluminous mordant be applied in patches or stripes, the cloth, when dyed up with the madder, receives, *throughout*, a permanent dye, which, after clearing in a soap bath, at a high temperature, is a bright full red in the mordanted portions, and a pale red, or pink hue on the unmordanted. This variety of shades forms a very agreeable style of the Adrianople work, and is in considerable demand for ladies' robes and furniture. It also gives occasion to a new variety of discharge work, according as the colour is removed, and new figured designs are introduced into the full red portions, the pale red, or into both.

Some extensive calico-printers conceiving that as the pale-red colour was produced on the cloth, without the direct application of the aluminous mordant, it ought not to be regarded as a true Turkey-red; and, that, therefore, it did not fall within the specification of Mr. Thomson's patent: under this impression, they began, without his permission, to apply his process of discharge with tartaric acid and chloride of lime. A suit at law having been instituted by him to prevent what he deemed an invasion of his patent privilege, the following series of experiments was made with the view of deciding by chemical analysis, whether the pink cloth contained the essential mordant of the full red, *viz.*, alumina.

If it did so, then the two shades differed not in the quality, but in the quantity of the dye, and might justly be considered as identical.

Various methods occurred, or were suggested for conducting the research. It was imagined that, if the pink portions of cloth moistened, were exposed to chlorine gas, the madder colour would be destroyed, and the alumina of the mordant might then be taken up by the resulting muriatic acid, from which it could easily be separated. Certain practical inconveniences, in operating on the requisite quality of cloth, prevented this plan from being carried into execution, on an adequate scale. An examination of

the ashes of the burned calico was, therefore, fixed upon as likely to afford the surest criteria of the presence and proportion of the aluminous mordant. But this plan could evidently lead to no certain conclusion, unless the composition of the ashes of the cotton fibre, or the undyed calico, was previously known.

Accordingly, 2000 grains of clean cotton-wool, in the soft fleece, formed by the cylinder cards, being carefully burned in a silver basin, yielded on an average of six trials, 19 grains of light gray ashes, which is a trifle under 1 per cent.

One hundred parts of these ashes afforded by lixiviation with boiling water, 64 parts of soluble saline matter, consisting of

Carbonate of potash . . .	44.8	
Muriate of potash . . .	9.9	64.0
Sulphate of potash . . .	9.3	

The 36 parts of matter insoluble, in water, were digested in dilute muriatic acid, nearly the whole dissolved with effervescence. This solution was then slightly super-saturated with solution of pure potash and boiled, to take up whatever alumina might be present. The mixture was thrown on a filter, and the liquid which passed through, was tested for alumina, by muriate of ammonia, but no trace of this earth could be found.

The pasty mass left on the filter, was then dissolved in dilute muriatic acid. By ferro-prussiate of potash, ferro-prussiate of iron was separated, which yielded 5 parts of ignited peroxide, of which 3 were derived from the cotton ashes. Ammonia was now added in excess. Phosphate of lime fell down, amounting, after ignition, to 7 parts, to which 2 must be added that were detected in the matter left undissolved at first by the muriatic acid, forming together 9 parts of calcareous phosphate.

Oxalate of ammonia separated from the last filtered liquor oxalate of lime, which changed, at a dull ignition, into 10.6 parts of carbonate.

Phosphate of soda being now added, threw down triple phosphate of magnesia and ammonia, which, when ignited, formed 8 parts of magnesian phosphate. The matter which resisted the

action of the muriatic acid, amounted to 24 parts. It was fused along with pure potash; the mass was treated with dilute muriatic acid, when the whole dissolved. This solution was super-saturated with pure potash, and thrown on a filter, in order to obtain the alumina. Only a faint trace of this earth was perceptible by the action of muriate of ammonia on the filtered liquid.

One hundred parts of the ashes of cotton seem to be composed by this analysis of

Soluble Matter.	
Carbonate of potash	44.8
Muriate of potash	9.9
Sulphate of potash	9.3
Insoluble Matter.	
Phosphate of lime	9.0
Carbonate of lime	10.6
Phosphate of magnesia	8.4
Peroxide of iron	3.0
	95.0
Alumina, (a trace)	.
Loss	5.0
	100.0

Those who have perused the series of elaborate analyses of the ashes of vegetables, made by M. Theodore de Saussure, will not be startled at the amount of loss in the result of the present experiments. In the excellent *Recherches Chimiques sur la Végétation* of this accurate philosopher, we have some remarks on the action of potash on the phosphate of lime*, from which I was led to imagine that the mode of analysis which I had pursued, might have occasioned some decomposition of this calcareous salt, and thereby vitiate the results. I, therefore, dissolved a mixture of known weights of phosphate of lime and alumina in dilute muriatic acid, and then added solution of pure potash in such excess as to ensure the thorough solution of the alumina. After boiling the mixture, it was thrown on a filter. On this, there remained the phosphate of lime, which, being well washed and ignited, amounted exactly to the 10 grains originally employed.

* Page 324.

I find that 40 grains of fused potash, dissolved in 260 grains of water, take up about 12 grains of alumina, which is nearly the equivalent proportion, adding alumina 18 to fused potash 57, on the hydrogen scale, or 2.25 to 71.25, where oxygen is unity. It was a pulverulent hydrate of alumina which was used, but its proportion of water was known and deducted. In the course of this inquiry, I also observed that a solution of phosphate of lime in dilute muriatic acid, which was very sensible to oxalate of ammonia, ceased to be affected by this calcareous re-agent, when a very little alum was introduced; or if a slight turbidity appeared, it was removed by the slightest heat. An equivalent increase of acidity occasioned by a drop of muriatic acid, did not prevent the precipitation of oxalate of lime.

2. *Experiments on White Calico-Cloth.*—4300 grains of washed white calico yielded only 18.2 grains of light gray ashes, from which, by the action of boiling distilled water, no soluble saline matter whatever was obtained. This insoluble incinerated matter was treated at a red heat with thrice its weight of fused potash; the mass was lixiviated with water, and thrown on a filter. The liquid which passed through was first super-saturated with muriatic acid, and then with ammonia, when a faint flocculence appeared. This was, at first, inferred to be alumina, but from its speedy subsidence and insolubility in potash, it was, probably, calcareous phosphate. The remaining 18 grains consisted of *sulphate of lime*, phosphate of lime, phosphate of magnesia, and oxide of iron in proportions, which it appeared unnecessary to determine with final minuteness, as I found the ashes of other pieces of white calico to differ very materially in composition from the above. I may here mention, however, that when phosphate of lime, and sulphate of lime are mixed together, they are easily separable by dilute muriatic acid. This fact is well known, I believe, to chemists. But that sulphate of lime is pretty soluble in single aquafortis, slightly heated, I have not seen stated in any chemical work; though the fact occurred to me in 1815, and I mentioned it in 1816, to a distinguished Fellow of the Royal Society in London.

In another experiment on white calico, a piece weighing 7129 grains, afforded 11.5 grains (about 1.6 from 1000) of ashes,

4 grains of these, or rather more than one-third part were soluble saline matter, containing 3.63 grains of carbonate of potash, mixed with a little sulphate and muriate. The insoluble matter afforded—carbonate of lime 4.45, phosphate of magnesia 0.4, sulphate of lime coloured with iron 1.0, silica 0.5, with a faint trace of alumina. Here the phosphate of lime, so abundant in the cotton wool, seems to have been removed from the cloth in the process of bleaching, and to have been partially replaced by sulphate and carbonate. In a third experiment, a piece of white calico, about 13 or 14 yards in length, weighing 11302 grains, was carefully burned over a silver basin in successive shreds, and the resulting spongy ashes were then ignited in a furnace. The residuary matter was of a grey colour, and weighed 37 grains, being about 3.3 from 1000 parts of cloth. Of these 37 grains, no less than 18.7 grains dissolved in boiling water. These 18.7 grains being evaporated to dryness, ignited and re-dissolved, were found to consist, by test nitric acid, and other re-agents, of 18.1 grains of carbonate of potash, and 0.6 of mixed sulphate and muriate. Nitre, equivalent to 18.0 grains of carbonate, was obtained in prisms. The insoluble matter was found to be composed of nearly the same substances as those above recited.

An inexperienced analyst may be apt to regard, as alumina, the precipitate obtained, on adding ammonia to a muriatic solution of the insoluble cotton-ashes; but this conclusion may be altogether erroneous, since phosphate of lime is thrown down by the same re-agent. The muriatic solution should, therefore, be supersaturated with potash, and thrown on a filter. The alumina, if present, will now pass through, in alkaline solution, and may be separated by solution of sal-ammoniac, or which is the same thing, by saturation with muriatic acid, and then with ammonia. But even this precipitate should be proved once more, by adding a feeble excess of potash, which will cause its instant disappearance, if it consist of alumina.

My communication, in the next number, will contain an examination of the ashes of the dyed cotton goods, and also of those

of the aqueous extract of madder; without reference to the latter of which, the results of the former may prove fallacious.

Glasgow, Dec. 16th, 1825.

Art. V.—*Account of the Improvements which have been made in England on the Reflecting Microscope of Professor Amici, of Modena. By* C. R. Goring, M.D.

[Communicated by the Author.]

The invention of the Amician microscope has produced a strong sensation on the Continent, where it is held in high estimation. The most pompous eulogies have been bestowed upon it in the foreign journals *, as an instrument likely to supersede the use of every other, having beaten the best English microscopes of Adams' and Dollond's manufacture, against which it had been tried, and excelled in power those made at Benedictbrunn by Utzschneider and Frauenhofer, &c.

Mr. J. Cuthbert, of 22, Bishop's-walk, Lambeth, (an artist well known as a maker of dumpy Gregorian telescopes), was induced to attempt the construction of one of these instruments, the object metal of which had an aperture of $1\frac{1}{2}$ inch, and a sidereal focus of 3 inches, being slightly different in its proportions from Amici's, of which the apertures are only 1 inch to a focus of $2\frac{6}{10}$ inches; the length of the tube was 12 inches, like that of the professor's. Mr. C. succeeded in obtaining an accurate figure in both metals, and bestowed much pains in bringing them truly into adjustment, but could by no means satisfy himself that the performance of the microscope realized any of the wonders he had been led to anticipate. It was evidently a coarse megalascope only. Having, in the course of my microscopical researches, discovered a set of objects of very difficult demonstration, I tried it with them, but could not procure vision of one. I believe Mr. Dollond has also

* Vide Gilbert's *Annalen,* and the Professor's own *Memoir,* in the 18th vol. of the *Transactions of the Italian Society.*

made an Amician microscope, with a result equally unsatisfactory. Now, it is idle to suppose that the incapacity of these instruments arose from any defect of execution: it can be no derogation from the dignity of Professor Amici to assert, that either Mr. Cuthbert or Mr. Dollond can figure elliptic metals as well as he can. I conceive that Mr. C.'s instrument had a certain advantage over the regular Amician construction, in possessing a larger aperture relative to its focus, which is evident from the proportions stated above. In addition to the disabilities I have already detailed, there was a very disagreeable nebulosity in the middle of the field of view, which arose from the image of the plane metal occupying so large a space in that of the elliptic one, as to leave only a narrow rim of reflection to enter the retina, so that the pencil of light at the eye-piece, examined by a magnifier, presented an appearance like that represented in the Plate, fig. 1. *a*. Whoever considers that the transverse diameter of the plane metal, in Amici's proportions, is $\frac{5}{10}$ inch, while the clear aperture of the other is only 1 inch, being at the same time 1 $\frac{6}{10}$ inch farther off from the eye-piece than the diagonal, will easily see that the image of the latter must be more than half the diameter of that of the elliptic; in Mr. C.'s it was just one-half, as I have drawn it.

It appeared to me nevertheless, that the principle of the instrument was essentially excellent, and only required to be carried into effect in a proper way, to form a microscope which should really deserve the character which had been too easily conceded to the original construction. From my experience in these matters, I was led to think that Amici, in order to procure facilities for illuminating opaque objects, had sacrificed the most valuable properties of his instrument, in making his object-metal of so long a sidereal focus; for I have always found (*cæteris paribus*) that those compound microscopes, whose object-glasses have the shortest solar focus, are sure to possess the greatest penetrating power, because they enable us to procure a high degree of amplification with a shallow eye-glass and a short tube. To the theorist it may appear a matter of indifference whether power is

procured one way or another, by a short tube or a long one, by a deep eye-glass or a shallow one; and, perhaps, if we could form images either by aplanatic refraction, or the reverberation of metallic surfaces, as perfect as their prototypes, such would really be the case; but human ability extends not so far. Magnifying power is far more valuable and effective when it is the free and spontaneous production of the object-glass, or metal, than when it is forced to yield it by the amplification of its image under the action of a deep lens. No doubt it is always possible to get a large image with a shallow object-glass, merely by lengthening its focus next the eye; that is, using a long body instead of a short one. But this is exactly similar to the method in which it is obtained in the solar microscope; and every one knows what a miserable dilated shadow is the result: the indistinctness is, as nearly as possible, similar to that produced by a deep eye-glass, effecting the same degree of extension in the image.

These considerations led me to recommend Mr. Cuthbert to make his object-metals (if possible) of only half an inch solar focus, and a quarter of an inch of aperture, and to reduce the length of the tube to four or five inches *. I likewise planned the present mechanical arrangements belonging to the instrument; and Mr. Cuthbert, with that liberality of spirit which characterizes a true genius, has done me the honour to adopt all my suggestions on these essential points, though his head, far more fertile in expedients and resources than mine, has enabled him to improve upon every thing I recommended. I think it

* The very first trial which was made with an object-metal of short focus (6-10th inch, with 3-10th aperture) gave a delightful foretaste of what might be expected from the instrument in this form:—all the test objects were instantly shewn with the utmost facility. I may observe, that the figure of the ellipse was pretty good; as to that of the plane it was detestable: adjustment there was none. So great was the difficulty of finding an effectual mode of adjusting such small metals, that I was at one time afraid an insuperable bar would be opposed to the manufacture of these instruments; all this is now completely done away with,—the purpose is accomplished in a way which leaves nothing to be desired, and in so firm a manner as not to be in the least subject to derangement.

just to mention that he did every thing at his own cost and risk, and moreover to express my conviction that the aid I afforded him was superfluous, as I have no doubt that he would, in process of time, by the force of his own unassisted talents, have effected the same radical reform in the old Amician construction which, from being more habituated to the subject, I was at once enabled to dictate.

As the case stands, I cannot but feel flattered with the compliment Mr. C. has paid me in submitting to take a lesson at my hands in his own profession—very few projectors having ever received this honour from an artist. We have I think a right to consider ourselves the legitimate parents of the instrument *in its effective condition*, as now presented to the public; though the merit of suggesting the *optical principle* unquestionably belongs to the learned Italian of Modena: for though an Amician microscope has an outward resemblance to a Newtonian telescope in miniature, yet it is in the exterior only; the form of the concave metal, and the situation of the radiant point and image being so totally different as to constitute an entirely new instrument. Sir I. Newton never contemplated any such conversion of his metals into a microscopic form; he indeed recommended an elliptic metal to form the image for a reflecting microscope merely, but it was simply by putting an object in its focus, so as to have only one reflection.

The Plate will, I hope, communicate a sufficiently accurate idea of the improved instrument, and render a very laboured detail in words unnecessary.

To begin from the foundation.—A B is the stand, which differs not from those of small telescopes, save that it has a draw-tube C, which is sprung at the bottom, and which enables us to increase the height of the microscope from 10 to 15 inches. The joint D is pierced, and has a small pin, E, to lock it fast when it is requisite to preserve the body of the instrument in a truly horizontal position; a socket with a pinching-screw at F serves to hold the body. This stand may of course be used for a small refracting telescope, as the body of the microscope may be removed en-

tirely from it with the utmost facility. The body G H is 6¾ inches i length, but has an internal tube to draw out to 9 inches: into the latter, the eye-pieces are made to slide *. The tube I, carries the metals, and screws on at K. Four sets have been made, of which the apertures and sidereal foci of the concaves are as follow;

Foci.	Apertures.
·6 inch.	·3 inch.
1· —	·3 —
1·5 —	·6 —
·4 —	·3 —

Mr. Cuthbert also proposes to make a pair, in which the elliptic one shall have only a focus of ·3 with an aperture of ·2 †.—All these

* These are 4 or 5 in number. The focus of the anterior eye-glass of the lowest power is ¾ inch, that of the highest 1-10th inch. They are so exactly similar to those of astronomical, refractory, and Newtonian telescopes, as to require no particular description; they will act almost equally well with any of these instruments. They are of course composed of two plane convex lenses, and are achromatic. I cannot here refrain from protesting against those preposterous accumulations of eye-glasses which we find in the best common compound microscopes (as they are called). It would appear that the worthy glaziers who preside over the destinies of these unfortunate instruments, have not yet discovered the right end of a microscope from the wrong one—at least they have vented their rage for improvement entirely on the eye-piece: having first doubled the anterior eye-glass, then tripled it, and finally interposed a body-glass of long focus between the field-glass and object-glass (making the eye-piece to consist in fact of 5 lenses), they sit down contented, and imagine they have arrived at the very extreme verge of perfection. The object-glass is allowed to remain a pitiful double convex lens, being I suppose either above or below their art! To say nothing of the hearty contempt of the science of optics displayed in the arrangement of these manifold eye-glasses, where every thing is sacrificed to the attainment of a large flat field of view,—there is such a flare and reflection from so many surfaces, that with a strong illumination of a transparent object, of such a description as to occasion the middle of the field of view to be a little dark while its edges are bright, two or three images may be perceived besides the genuine one, together with a bright luminous spot just in the centre of the field. These deceptions never occur with only two eye-glasses.

† These latter proportions can only be used for transparent objects, because the radiant point will be quite in contact with the tube, and therefore preclude the illumination of an opaque body. The same may be said of the last in the table (·3 aperture to ·4 focus). That of ·3 aperture to ·6 focus is a capital working-metal for all regular microscopic subjects—it leaves 1-10th

metals are secured from dust and damp by having a cap to screw upon their open end when not attached to the body, and also a segment of a tube, *e*, to close the aperture, by which the rays of light enter the instrument; being moreover fixtures in their tubes, it is hoped that they will be beyond the reach of those mischievous, though well-meant, wipes from officious persons, which are so ruinous to all reflecting instruments. I may here remark, that the transverse diameter of the diagonal metal in the improved state of the invention does not exceed one-third of the aperture of the other, and does not produce the slightest nebulosity in the middle of the field of view: a representation of the pencil is given at fig. 1. *b*.

The dependent bar, L M, 4 inches in length, is firmly attached to the neck of the body by a socket and clamping-screw N. It is triangular, having a rack-work at its posterior edge, and is perfectly steady and true in its motions. The stage O differs not from those of other microscopes; it has a condensing lens P, which is thrust into the tube Q either way, so as to serve to illuminate both opaque and transparent bodies, its double motion enabling it to act either above or below the stage.

The mirror R is a plane *; its reverse would be best occupied by a surface of plaster of Paris, to reflect the direct rays of the sun, which forms an excellent kind of light for transparent bodies,—a concave mirror, in my opinion, always produces indistinctness, along with an increase of light.

As many are fond of that kind of illumination for opaque objects which is produced by silver caps, though it admits not of

inch of distance between the object and tube, with any power; and therefore admits of the requisite illumination being thrown on an opaque substance as effectually as if the interposed distance was $\frac{1}{2}$ inch. The other two pairs may be considered as chiefly useful for the coarser and more ordinary classes of objects, especially if opaque.

* This mirror has $1\frac{1}{2}$ inch of clear aperture, so that when at its proper distance from the body a miniature image shall be formed of it in the visual pencil as large as that of the object-metal: transparent objects, it must be recollected, are seen by intercepted light, which this mirror is to furnish; it therefore follows, that if it is not of the proper diameter it will cause a mutilation of the pencil, and a loss of light, similar to what would arise from closing up some of the superficies of the elliptic metal.

our verifying the nature of an object by observing the play of light and shade upon it, (there being only a confused blaze of light obtained in this way, without any relief or contrast from shadows,) the condensing lens S is made to occupy the site of the mirror, which is removed by slackening one of its swivels; the cap T then slides upon the tube containing the metals, and the body being made to revolve round in its socket F, till the end of the dependent bar is pointed towards a lamp, or some other source of illumination, the proposed end is obtained as in other microscopes.

As to the rest of the apparatus belonging to this microscope, it is so similar to that attached to others, that it is not necessary to describe it, with the following exceptions:—U is an aquatic lice-box, formed by causing one piece of tube to slide within another, and burnishing a piece of plate-glass into the end of each, with a little wax interposed, so as to render the enclosure watertight: a small hole is pierced in the external tube, as near as possible to the glass, to admit of the escape of air, a quantity of water, containing animalcules, &c., being then poured into the exterior tube, the other is inserted into it, being first slightly greased; then by causing the little hole to assume a vertical position, and at the same time compressing the inner tube, the air is easily expelled, and as much of the water also as may be superfluous. This piece of apparatus makes a better sort of dry livebox also. It may be made of any dimensions, or only of the size represented in the Plate, and should have a bit of plate-brass V, with an aperture in it, to receive the shoulder on its inferior end: a small notch made in the brass-plate at W receives the head of a screw X, and secures the whole together under any circumstances of position. The plate is passed into a slider-holder, and then the box is inserted in its place, when the whole may be moved in any direction to follow the motions of insects, &c. At Y is a contrivance of a similar nature: it consists of a strip of plateglass, having a piece of talc cemented upon it, with a small space interposed to contain a drop of liquid: one side is left open or closed at will with a bit of bees-wax; this serves to hold ani-

malcules or salts for crystallizations: the talc prevents the evaporation from steaming the metals, and thus interrupting observation. Z is the slider-holder belonging to the instrument: it is constructed with four pillars, connected in one direction by cross bars, which serve to keep down a slider in its proper position, while they allow the tube containing the metals to become a tangent to the surface of any thing inserted for examination. There is a notch in the stage, and a corresponding catch in the bottom of this piece of apparatus, similar to that already described in the live-box.

At fig. II, is a contrivance of Mr. Cuthbert's for converting the instrument into a single microscope of the best construction;—a piece of brass, *a*, is made to screw upon the body of the microscope in place of the metals: a square socket, *b*, is made in it to carry an arm, into the end of which the magnifiers are screwed in the usual way; a joint is made at *c* to allow of lateral motion in the lens, while the sliding-bar completes it in the opposite direction, according to the impulse given by the observer.

Fig. III, is another arrangement of Mr. Cuthbert's, by which he converts the reflecting instrument into a compound refractor:—*a*, represents a frustrum of the body, as before, and *b*, that of the bar, which are now connected together by a double clamp at one end *c* grasping the neck of the tube, and at the other *d* grasped by the neck of the bar, and secured by means of the pinching screws *e* and *f*. At *g* is a diagram of an object-glass; it consists of two plane-convex lenses; the focus of the anterior one, *h*, being to that of the other, *i*, in the ratio of two to three, while the distance between them is one; the flat sides are both turned towards the radiant; a clamp *k*, behind the posterior lens, regulates the aperture.

I have recommended this sort of object-glass to Mr. Cuthbert in preference to a common double convex, like those in common use, because with any given power and aperture it can be proved to have only one quarter of the spherical aberration which they have. At *l*, this combination is represented attached to the body.

Fig. IV, is a section of a slight alteration in the construction of the Amician reflector, which I have contrived, for the sake of

causing it to act with concave metals of unlimited angles of aperture. It must be evident that in the proper acting form of the instrument, if an elliptical metal is used of much more than 30° of aperture, its focus must fall within its containing tube, unless the size of the diagonal is increased to an injurious degree, and approximated very near to the concave one. But if we slit the sides of the containing tube at *a a*, and introduce transparent objects contained between pieces of talc *b b*, so that they shall approach very near to the plane *c*, it is evident that in this way the concave metal, *d*, may be made to operate with a very large angle of aperture, say 60°, without requiring any increase in the usual diameter of the small one. The containing tube must have a large aperture opposite the face of the diagonal at *e*, and an outer tube must slide over it, having a hole in it at *f* to admit light, and slits at the sides, *g g*, to prevent injury to the slide when it is moved about for the purpose of giving, when required, an oblique direction to the intercepted rays. This innovation is inapplicable to opaque objects. Fortunately, however, the latter do not require object-metals of such large angles of aperture as some transparent ones have been found to do: it may appear, *à priori*, that objects seen by reflected or radiated light should naturally require larger apertures than diaphanous ones rendered visible only by arrested rays. There is, however, I think no opaque object requiring so large an angle as even 30°, while there are some kinds of dust of butterflies' wings which require 40° and 50°, or even 60° (at least with uncorrected single lenses); thus a lens of $\frac{1}{20}$ inch focus must have $\frac{1}{20}$ inch of diameter also, to show the fine lines on some of these objects. But when we employ metals of accurate figure, or object-lenses made achromatic, to form an equivalent compound instrument, a less angle seems to suffice, say 40°, because the aberration being extinguished, the marginal rays are all rendered efficient. Many of the lines on the scales of moths and other insects are seen completely well as opaque bodies, with an aperture almost inadequate to show them at all as diaphanous subjects (for in many specimens they are visible in both ways). When I assert that certain objects are invisible

without certain angles of aperture, this must be understood to apply to all powers, even when aided by the most vivid artificial illumination. From my own experience, I am inclined to think 15° or 20° quite enough for ordinary objects, both transparent and opaque, though the beauty of their *colour* is much heightened by a larger aperture.

With respect to the mode of using the Amician microscope little need be said; it is managed like others; all that is requisite is to present the object opposite to the aperture (fig. 1. *c*) in the tube which contains the mirrors, so that it shall be in the focus of the elliptic one: the rays diverge towards the plane diagonal, and are from thence reflected towards the concave *d*, from which they are reverberated into the other focus of the ellipse *e* (which is the field-bar of the microscope), and there form a magnified image of the object which is viewed by the eye-glass. Nothing can be more convenient than this instrument for viewing naked liquids and other objects, merely secured on the stage by their gravitation, because the eye can always preserve its natural direction without looking downwards from the horizontal position of the body of the microscope. There can be no doubt that in many individuals, continued stooping and poring downwards over a common microscope contributes to determine the blood to the head and eyes, and ultimately proves very debilitating and injurious to the sight. The illumination must be accomplished in the usual manner as long as the instrument is used in the condition in which it is drawn in the Plate—but with all objects contained in sliders and similar apparatus admitting of their being presented for examination in any position, it is much better to remove the large mirror, and merely to turn the end of the dependent bar M towards the light, by causing the body G H to revolve about in its socket F, and at the same time adapting the motion of the cradle-joint D, to suit the circumstances under which it has to act, and the angle at which we choose to look through the instrument. Many beginners are much puzzled with regard to the method of managing illumination derived from a concave mirror, till they have arrived at practical dexterity in adapting it to the angle of

incidence and reflection required to cause a cone of rays to pass through the microscope. All this is completely done away with in the simple manner described above.

As to the kind of illumination best for the Amician microscope, it must be left to those who use them to determine. I think a common tallow-candle does as well as any thing, and is extremely manageable for all objects. It does not, however, answer for animalcules and other similar bodies, though it causes them to be seen with a very sharp, well-defined outline, because the internal machinery of their transparent forms is rendered confused and unintelligible by this kind of intercepted light. Daylight better develops the contents of these bodies, while it renders their rotatory fibrilla and hairs much fainter. Thus I can never see the young eels which are contained within the full-grown ones in paste, nor the eggs and bowels of the wheel animalcules by candlelight, though I always see the wheels of the latter better with it. I think it will be found that, generally speaking, those bodies which require a large angle of aperture will be seen best by lamp or candlelight, while those for which a small one suffices will be best exhibited by daylight. Of course the natural light of the atmosphere must always be resorted to, when we want to ascertain the real tints and colours of objects; lamplight varnishes them with a yellowish-brown tint, which is unnatural; yet, from the contrast of oblique light and shade which it affords, it brings out and verifies the forms and positions of bodies, with their perspective and foreshortening, in that strong and decided manner which we admire in those pictures which represent a torch or candlelight scene.

As it is the established and immemorial practice of all projectors and improvers to extol the merits of their own inventions, and to decry others, I shall merely state a few facts, which are perfectly accessible to the examination of the public at large *, relative to the properties of the improved instrument. First, then, it appears to labour under the same inconvenience with the Gre-

* Mr. Cuthbert will be proud to exhibit the microscope to the curious, who are invited to try their own against it.

gorian telescope ; *viz.*, that it cannot be made to act with a low power without having a contracted field of view, and a nebulosity in the middle of it ; by no arrangement can this be obviated ; the lowest power it will act well with is equal to that of a single lens of $\frac{1}{6}$ of an inch focus *, or 48 (reckoning by a standard of sight of 8 inches). If this defect is looked over (if such indeed it is), it may be considered as perfect an instrument for viewing near objects, as reflecting telescopes are for distant ones. I suppose it will be admitted, that if single microscopes could be made of sufficient power and aperture, without possessing aberration of either kind, it would be vain and ridiculous to attempt to surpass them by any compound instrument in which a magnified image is viewed instead of the object itself, as in the former. But it is well-known that we shall never procure an aplanatic single microscope of $\frac{1}{20}$ inch focus. Now I have ascertained, and so may any person who chooses to give himself the trouble, that there are certain objects invisible with the best single lenses, unless they have a certain angle of aperture—thus, if a lens of $\frac{1}{20}$ inch focus has not an aperture of about $\frac{1}{40}$ inch, it will not be able to demonstrate the ribs and lines on the more difficult kinds of dust of butterflies' and moths' wings, &c. But the aberration with this angle of aperture will be considerable, and more than equal to the thickness of the lens employed, be it of what figure it may. Doubtless, considered as a measured quantity, this is small, and continually growing less, as the focus and size is diminished ; but whatever may be the smallness of the lens, its longitudinal aberration will bear the same ratio to its focus as in larger ones, and create the same indistinctness with any given angle of aperture. This defect may be rendered manifest in the following manner :— Procure a small piece of the dial-plate of a watch, in which the figures are enamelled white on a black ground ; view it with a

* This is the chief reason of the adaptation of the single and compound refracting microscope to the reflector, because with these instruments all the low powers may be obtained in the usual way. Under different circumstances, it would be very preposterous to pretend to assist the operation of the Amician instrument by any other.

single lens, having an angle of aperture of 30°; let it be, for example, one of $\frac{1}{4}$ inch focus and $\frac{1}{8}$ inch of aperture, or use any other of the same proportions which is preferred, only let it not be so shallow that the pupil of the eye shall be able to cut off any of the marginal rays, as it would, for example, in one of $\frac{1}{2}$ inch focus and $\frac{1}{4}$ inch of aperture. Now such a lens will by no means define this excellent test-object; instead of separating the white clearly from the black, it will disperse it over the confines of the black in the form of a nebulosity or fog: if the illumination is pretty strong, the colour will also be rendered very sensible at the boundaries of the black and white, especially when the object is put out of focus. But an Amician microscope will, *if the metals have been truly figured, and the eye-piece also rendered aplanatic*, shew this object without any aberration whatever of either kind, and this it will effect with a visual pencil of light equal in size to that of the cylinder of parallel rays proceeding from a single microscope of the same power, and having the same angle of aperture with its objective metal. It may not be generally known that the pencil of light at the eye-piece of all compound microscopes bears the same ratio to the focus of a single lens of equivalent power to the compound instrument, that the aperture of its object-glass or metal bears to its acting focus, measured from the radiant point, so that we may, by ascertaining the size of the said pencil by a dynameter, and comparing it with the ratio between the aperture of the object-glass and its focus, at once determine the power we are using. To apply this to the Amician microscope, let the aperture of its object-metal be $\frac{3}{10}$ inch, and its acting focus $\frac{6}{10}$, and I find by admeasurement that with a particular eye-piece the size of the pencil is $\frac{1}{40}$ inch,—I immediately know that the power must be equal to that of a lens of $\frac{1}{20}$ inch focus, $\frac{1}{20}$ inch bearing the same ratio to $\frac{1}{40}$ that $\frac{3}{10}$ does to $\frac{6}{10}$. (This digression is necessary to illustrate what follows.) It will be found by experiment, that all objects can be seen with the reflecting microscope which can be rendered evident with single lenses of the same power, having the *same angle of aperture with its objective metals respectively*, and conse-

quently the same light. This is the law which governs the relations between these two kinds of instruments. It must never be forgotten that a microscope having to deal with diverging rays is by no means in the predicament of a telescope acting with parallel ones, as concerns what may be called the magnitude of its aperture; in the microscope this evidently can only be reckoned by the angle which the diameter of its object-glass subtends with the object when placed at its acting distance from it: thus an objective metal of $\frac{3}{10}$ aperture, and only $\frac{6}{10}$ focus, must be said to have a larger aperture than one of $\frac{5}{10}$ aperture and $1\frac{1}{2}$ inch focus, &c.

It will occur no doubt to every one who attentively considers the subject, that the single microscope must inevitably have the advantage over the Amician in point of brilliancy, because the intensity of the light of its cylinder of parallel rays is not weakened by two reflections and two refractions, nor by a blot in the middle of it as in the other; and such certainly is the true state of the case; but it must also be recollected that the microscope does not resemble a telescope, which can have no light but what naturally proceeds from the objects viewed by it. In the former we can increase the brilliancy of an object at will by artificial illumination, and even in this way get much more light than we want; so that by rendering the brilliancy of the radiant body in the reflecting instrument a little greater than in the single one, the eye is no longer able to appreciate the differences between them.

The conclusion I am inclined to draw myself is, that, provided the image of the reflector is not amplified too much by its eye-glasses, say not forced beyond a power equal to a $\frac{1}{30}$ or $\frac{1}{35}$ of an inch (which is enough for any object I ever met with), it has an advantage over single microscopes, in exhibiting all the objects which can be rendered visible by them, totally free from aberration, either chromatic or spherical. The powers can always be augmented *ad libitum*, as in the telescope by deep eye-glasses, or by drawing out the inner tube. In trying the Amician micro-

scope against others, care must be taken that the powers of both are equalized *, for the better a microscope is, the lower will be the power necessary to make it discriminate properly any difficult object. A common compound microscope may be made to shew any test-object in the following manner:—Select for its object-glass the magnifier of a single microscope, having the power *by itself* of shewing the object you want to see in the compound one: let us suppose $\frac{1}{30}$ inch is required for this purpose; attach the compound body to it, and you will be sure to have your object in the field of view, only you will, by this operation, about quadruple your power, or make it equal to $\frac{1}{120}$ inch, and yet see infinitely worse than before—a vast improvement this on the single microscope, and much to be depended upon, no doubt, for making discoveries!—forcing you to use an object-glass of $\frac{1}{30}$ inch focus, and a power of 960, to shew what you will see with an Amician metal of only 1 inch focus, and a power of 240, or perhaps much less. Now a man who has an imperfection or defect in his sight, which causes him to see one object incorrectly, or imperfectly, may be justly supposed to see all others in the same way, and this will apply in a great measure to microscopes. If we can detect their false testimony in regard to one object, we are justified in suspecting it in all instances, though it may be possible that, like other liars, they occasionally speak the truth. I am certain that not the least dependance is to be placed in common compound microscopes, except for the purpose of shewing objects which happen to be visible with very small angles of aperture. All their low, useful, working powers being procured from object-glasses of very restricted apertures, are in this predicament. They will not, for an instant, bear comparison with single lenses. As to the very high powers, if procured by deep object-glasses

* Not only should the actual magnifying power be rendered the same in both, but it should be procured in the same way, that is, the body and the eye-glass should be the same in both instruments, and the object-metal of the same focus with the object-glass of the opposing microscope; in this way, the merits of both are completely and fairly exhibited.

and shallow eye-glasses, they act better in proportion with large apertures, than the lower ones, because the chromatic aberration is in them less sensible, from the small quantity of light which very deep objective lenses can admit, which moreover are, by their own intrinsic power as single microscopes, capable of doing a great deal. Still, however, I can only consider the common compound microscopes of commerce as mere toys, without a grain of science in their composition, fit for little else but to shew ladies a wood-cutting, and unworthy of the confidence of an observer. If a radical reform is not made in their construction by achromatic object-glasses, I shall expect that the Amician microscope will supplant them, for it can be produced at an expense not greater than that of the best of this class of instruments. Compound microscopes, both refracting and reflecting, can be placed completely on the same footing with telescopes, and reduced to the same accurate discipline in their construction. They are in fact nothing but telescopes, adapted to act with diverging rays, instead of parallel ones; the term *Engiscope* would, perhaps, be very applicable to them in their perfect form.

I feel myself called upon to state to the public, that Mr. Gill has given a mutilated and surreptitious account of the instrument I have described, in his *Repertory* for November last, which has moreover been copied into the *Quarterly Journal* for January, 1826, under the designation of *Mr. Cuthbert's Reflecting Microscope*, as if it had been originated by that acute and distinguished artist, instead of Professor Amici. I heartily hope this illustrious Italian may one day be gratified by an inspection of his invention in the mature and perfect state to which it has arrived in our tramontane climate.

Art. VI. *Outlines of Geology; being the Substance of a Course of Lectures on that Subject, delivered in the Amphitheatre of the Royal Institution of Great Britain, by* William Thomas Brande, F.R.S., Professor of Chemistry in the Royal Institution, *&c.*

[Continued from Volume XX, page 259.]

VIII.

I have attempted in the preceding lectures to lay before you a simple statement of the manner in which the strata incrusting the solid nucleus of our planet appear to be arranged in respect to each other; and I have occasionally, where any remarkable circumstances connected with geological theories presented themselves, adverted to those theories, with a view of briefly showing their comparative merits, but chiefly with the intention of proving the emptiness and insufficiency of most of those contending opinions which have been maintained respecting the origin of rocks, and respecting the manner in which they were deposited in their present situations. The substances which now remain for our examination are certain rocks which are very variable in their position, occurring sometimes in the company of the primary series, at others among the newest of the secondary deposites; rocks, the igneous origin of which cannot, according to the Huttonians, be questioned upon any sound principles of philosophical analogy; but which, if we believe the Wernerians, are decidedly of aqueous parentage. They constitute the whinstones, basalts, and greenstone of the one, and the trap-rocks of the other school.

The term trap-rock has been especially applied to those peculiar step-like or scalar declivities which mountain masses of this substance sometimes present.—In employing this term, I shall rather use it as a generic name of the rocks in question, than specifically as implying the material of which they are composed, and since the varieties known under the names of basaltes, greenstone, toadstone, and amygdaloid belong to this same class, and frequently graduate into each other, I shall occasionally employ those names as characterizing individual specimens of

trap-rock; designating the fine-grained and apparently almost homogeneous rock in many instances by the term basalt; the paler and greenish varieties which especially occur among the older rocks, and sometimes approximate to the nature of sienite, by the name of greenstone; while the porous varieties, and those containing nodules of calcareous spar, quartz or agate, zeolites, &c., may be called amygdaloid; and the term toadstone may be confined to the speckled varieties of whin or trap-rock, which abound in Derbyshire. Pitchstone, too, I cannot give a better place to than among these rocks.

In regard to these rocks generally, it may be remarked that they can scarcely be said to be *stratified*; at least in this respect they are as equivocal as granite itself; like it they form irregular masses and veins, sometimes upon and sometimes under other rocks, sometimes interposed between them, and in almost all their varieties an analogy may be traced out to the lavas produced by the superficial volcanoes of the earth. Indeed, the resemblance is sometimes so great, that many geologists have mistaken whinstone for lava, and many rocks regarded as the remains of extinguished volcanoes have proved to be true basaltic formations.

Hornblende and felspar are distinctly visible in some of the unequivocal varieties of trap-rocks—the former very abundant, and the proportion of black oxide of iron being such as to give to the substance a decided magnetic character. In other cases distinct crystalline texture is lost, and the mass appears nearly or quite uniform and homogeneous.

This rock, under the name of greenstone, is seen in characteristic masses associated with the granite, mica-slate, and serpentine of the Lizard in Cornwall. It is seen accompanying clay-slate and old red sandstone near Kington and Radnor in Wales; and upon the northern sides of Snowdon, Plynlimmon, and Cader Idris, coarse-grained and with regular crystals of hornblende in one place, and in another fine-grained, homogeneous, and even basaltic or columnar.

In Derbyshire, under the name of toadstone, I have already noticed the singular disposition of this rock associated with

mountain limestone; and with new red sandstone, or red marle in the coal-fields of the north, near Edinburgh, in Shropshire, and elsewhere; and in Antrim we find it variously blended with the sandstones and chalk, and even sometimes lying upon them, so as to constitute beds superior to those of the newest secondary formations.

These instances, which might be greatly multiplied, will suffice to illustrate the varied position of this rock. In regard to its aspect, we observe it in Cornwall forming blocks and masses not unlike the granite of that country; sometimes, as in the coal-strata, it forms immense walls or *whin-dykes;* in Derbyshire, it may be said to be stratified; in the Isle of Mull, and elsewhere, it is massive and amorphous; and in many places it is columnar, of which the coast of Antrim, the Island of Staffa, and some parts of Mull, furnish such magnificent instances. The Isle of Mull, Ulva, and the Treshamish Isles, exhibit trap-rocks and veins in such variety, and more especially the Isle of Mull, which is also highly interesting as a school of granitic geology, that I am sorry to pass it over with a bare mention. The trap-veins of the Isle of Sky are not only remarkable for their singular extent and arrangement, but for the changes which they produce upon the rocks they penetrate, and which are of such a nature as to throw some few rays of light at least upon the most recondite chemical phenomena connected with geology. I do not mean to say that these peculiarities belong exclusively to Sky, for they are more or less distinctly observed among all similar associations of rocks, but in that island they are eminently distinct.

Among these veins there are two which penetrate the white marble of Strath, (Mac Culloch, i. 399,) and which have been exposed by the operation of quarrying. Now, the mere fact of the vein passing through marble is not common, but what is truly curious is, that at their junction the trap passes into a substance resembling serpentine and penetrated by fissures containing steatite; while the marble acquires all sorts of colours, and changes in composition from argillaceous to magnesian, and from magnesian to siliceous. Among the veins of Strathern, a similar

connexion between the veins of basalt and steatite, and serpentine and marble, also occurs; but there the veins instead of penetrating marble are in calcareous sand. Also in Glentilt, and in various other parts of Sky, trap-veins intersect and cut off coal formations, and sometimes the same vein of trap exhibits the rock in its several varieties of basalt, greenstone, and amygdaloid. I do not endeavour to state the names of the particular places or spots at which these appearances occur, for they defy all ordinary powers of orthography, but many of them are accurately laid down and described by Dr. Mac Culloch in his laborious geological work upon the Western Isles of Scotland—his descriptions are so minute and his observations so perfectly untinctured by geological prejudice, as to leave the student nothing further to wish for in that line of description.

Of Staffa, Dr. M. has given us a minute and accurate account, enriched by a variety of remarks of infinite use to the traveller, who has here to navigate a dangerous sea, at the mercy of a very ignorant and imposing class of persons.

Staffa is about a mile and a half in circumference, and its greatest elevation, which is upon the south-west side, is about 144 feet. Its lowermost bed upon that side is a basaltic conglomerate. The columns are compact and uniform in texture, of a dark grayish-black colour interiorly, and of a rusty-brown where exposed to the weather. Amorphous and columnar basalt, and a stratum of pebbles foreign to the island, which were referred to in my first lecture, form its upper bed, or stratum.

The most celebrated object in this island, and justly so, too, is Fingal's Cave, though there are two others of considerable grandeur and interest. The entrance to this cave resembles, in shape, a Gothic arch, about 70 feet in height; the pillars which bound it vary from 18 to 36 feet in height; its breadth is between 40 and 50 feet, which is also the average height of the interior; its length is 227 feet, and preserves a considerable degree of regularity throughout, its sides being columnar, and, in many places, broken and irregularly grouped, so as to catch a variety of direct and reflected tints, mixed with unexpected shadows, and pro-

ducing, as Dr. M. has well observed, a picturesque effect, which no regularity could possibly have given. The sea never entirely ebbs out of this cave, but the broken range of columns which forms the exterior causeway, is continued on each side within it, forming upon the east a footpath, which is so irregular, slippery, and broken, as not to be traversed by any but those possessed of a very steady foot and head. This cave has been frequently described, but no description is adequate to the representation of its varied beauties and singular associations. Dr. Mac Culloch, who has frequently visited it, and each time with new admiration, has justly observed, that were it even destitute of that order and symmetry, that richness arising from multiplicity of parts, combined with greatness of dimensions and simplicity of style, which it possesses, still the prolonged length, the twilight gloom half concealing the playful and varying effect of reflected light, the echo of the measured surge, as it rises and falls, the pellucid green of the water, and the profound and fairy solitude of the whole scene, could not fail strongly to impress a mind gifted with any sense of beauty in art or nature.

The uppermost basaltic bed of this island consists of a confused mass of small columns and is of variable thickness, its naked surface having a singularly tessellated appearance. This bed forms, in the language of architecture, the entablature required to give their due office to the columns which form the middle range.

Another cavern in this island deserves notice, as a contrast by its irregularity, to the regular columnar arrangements of Fingal's Cave; it is usually called Mackinnon's Cave, and is more easy of access than the former. It presents a large entrance, about 50 feet square, and extends to about 250 feet into the rock of conglomerate; while the superior part of the front consists of a range of columns, hollowed into a concave recess above the opening, and overhanging the concavity like a geometric ceiling.

A third cave, rarely visited, but curious from the singular grouping and regularity of its columns, is called the Boat Cave; its dimensions, however, are greatly inferior to those of either of the former.

The Giant's Causeway, and the various promontories or headlands of the coast of Antrim, form another basaltic district of matchless grandeur and interest; yet, to prevent the disappointment which I experienced in visiting these wonders of nature, after having seen the still superior and more insulated magnificence of Staffa, I would advise the traveller who has the choice, to proceed first to the north of Ireland, and thence to Staffa, for although Bengore, Pleskein, and Fairhead are in themselves superior to any part of Staffa, they do not rise in the same abrupt manner from the ocean, and being everywhere accompanied and surrounded by lofty cliffs, are not calculated to excite those mingled emotions of surprise and admiration, which so overpoweringly assail him who lands, for the first time, on the columnar and cavernous shore of Staffa.

The Causeway itself consists of three piers of columns, which extend some hundred feet into the sea, and are walled round, as it were, by precipitous rocks, from 2 to 400 feet high, in which are several striking columnar assemblages, vertical, inclined, curved, and horizontal, and in some places looking as if wedged or driven into the surface of the precipice, the ends of the columns only remaining in sight. Bengore, which bounds the Causeway on the east, consists of alternate ranges of tabular and massive, with columnar basalt; but amidst the various and grand objects of this coast, Pleskein is perhaps the most striking: it presents several colonnades of great height and regularity, separated from each other by tabular basalt; and at Fairhead there is a range of columns of from 10 to 20 feet diameter, and between 200 and 300 feet high, supported by a steep declivity, which forms a stupendous terrace nearly 600 feet above the waves beneath. Sometimes basalt rises in massive and abrupt rocks, assuming the appearance of an uniform and homogeneous substance, and scarcely exhibiting any of that singular tendency to columnar regularity, which we have just had occasion to admire in Staffa; the Castles of Dumbarton, Edinburgh, and Stirling, are built upon such masses. At other times it forms low, rugged, and unpicturesque strata, sometimes very remarkably bent, but without forming decided columns.

Basalt is not unfrequently found in veins, traversing masses

of the same substance, and of other rocks; and the phenomena which these veins produce in their passage, depend, of course, upon the nature of the materials traversed; they are, however, in most instances, such as to leave, independent of any other consideration, the most unequivocal marks of their igneous origin. Thus the veins, or dykes, are generally most crystalline in the centre, and acquire a more even and fine-grained fracture upon their sides; they harden and consolidate the lapideous substances through which they pass, producing effects analogous to those which may be conceived to result from the operation of matter in igneous fusion, injected among the strata, and which Sir James Hall succeeded in imitating artificially, by submitting the substance to the action of intense heat, under a pressure suitable to restrain the escape of gaseous matters. The sandstone near Edinburgh is thus hardened by the action of the whin-dykes, and there, in their immediate contact, it becomes of a jaspideous appearance and fracture; and in some places pieces are broken, and have been apparently floating in the matter of the dyke, and are proportionally hardened and modified. These appearances will, no doubt, recall to you the changes effected in the slate of Cornwall and elsewhere, by the veins of granite, and of porphyry, or elvan; but some of the difficulties, in regard to their origin, which I hinted at in my last lecture, do not apply to veins of greenstone and whin-dykes, which are certainly of less equivocal origin.

The limestone of Antrim alternates with basalt, and is in many places invaded by its dykes or veins, and in some overtopped by basaltic strata connected by small and narrow ramifications, with inferior or underlying masses of the same rock. Here we have the limestone changed to marble, and the flints putting on that opaque and red appearance which they are well known to acquire when subjected to artificial heat; but the fact which of all others favours the igneous original of basalt is derived from an examination of the changes which it effects in traversing coal-strata. The dislocations and fractures of the coal-field have been already described as one consequence of whin-dykes—another is the formation of chasms, in which carburetted

hydrogen is pent up under great pressure, and which, when any accidental opening is made into them, continue to emit torrents of that gas, forming what the miners term *blowers;* and what is also equally to the purpose, the coal is found charred or turned into coke in the vicinity or contact of these dykes.

Now, if we consider these facts, and if we associate them with others of a similar tendency; if we connect the theory with the experiments of Sir James Hall, and above all with those of Mr. Watt upon the fusion and cooling of certain earthy compounds, we shall not, I think, refuse to assign the highest degree of plausibility to that theory which compares basalt to lava, and considers it of igneous origin; and consequently also to those parts of the Huttonian doctrines which are mainly founded upon the phenomena and effects of whin-dykes.

Basaltic rocks vary extremely in their tendency to decomposition. In some places they are seen in rapid decay, crumbling down into a brown or red soil of a tenacious clayey character. In others they are of great and even remarkable permanence, and the columnar varieties are so little acted upon, that in the Causeway and Staffa, and upon many parts of Mull, the pillars retain the acuteness of their angles, although subjected to the incessant operation of the waves, and to those alternate exposures caused by the tides, which so few rocks are able to resist. Where massive basalt or trap-rocks are pervaded by veins of the same material, the vein is usually more indurated and durable than the mass which it penetrates, and not unfrequently the course and dimensions of the vein may be traced in relief upon the comparatively worn and degraded surface of the rock which it passes through.

In the Isle of Sky there is a large district of decomposing trap-rocks, which may well be selected in illustration of the decomposition of basalt. The north-east portion of the island exhibits a long ridge, commencing at Portree, and stretching away to the point of Aird, which, rising by a gradual acclivity from the west, terminates to the east by a rapid descent, often displaying extensive precipitous faces, and acquiring an altitude of upwards of 2000 feet. At the highest point, called the Storr, the summit of

the mountain is cut down in a vertical face 4 or 500 feet high; while the steep declivity below is covered with huge masses of detached rock, which are the more indurated and durable remains of the cliffs above. These are combined in various and intricate groups, while their massy bulk and squared and pinnacled outlines present vague forms of castles and towns, resembling, when dimly seen through the driving clouds, the combinations of an ideal and supernatural architecture. The most remarkable of these insulated masses is 160 feet high, assuming at a distance the aspect of a spire, and presenting from afar a sea-mark well known to mariners.

Having taken frequent opportunities of adverting to the proofs illustrating the igneous origin of basalt, it might possibly be expected that I should have equally described the phenomena belonging to this formation, which are supposed to demonstrate its aqueous production. Upon this subject, however, I should presume that a very few and brief observations will suffice. As far as basaltic dykes are concerned, it has been imagined that fissures existing in the rocks they traverse have been filled by an aqueous solution of the materials found in the dyke, and these, from some cause, by no means apparent, to have consolidated. Then, as to all those appearances of induration and fusion which I have elsewhere referred to the heat of the matter of the dyke; they are supposed to have originated in the solution having percolated and congealed in the walls of the vein. But the nature and extent of the hardening, and the various characters, both of the vein or dyke itself, as well as of the pervaded rocks, are surely more consistent with igneous eruption than with aqueous infiltration; to say nothing of a host of other objections which present themselves, and which I shall more particularly insist upon when adverting to the Wernerian hypothesis of the filling of metallic veins. Indeed in coal-mines we have too decided evidence of the igneous origin to substitute any other hypothesis.

In respect to columnar basalt, the Neptunians are yet more inconsistent with the facts which its minute examination affords.—They here refer us to that columnar appearance which certain substances assume on passing from a pasty to a solid state during

their desiccation. Something of this kind may be seen in starch, and occasionally in mud, which in the process of drying has split into irregular angular masses. But to say nothing of the state of the iron in basalt, or of its insolubility, there should in such a case have occurred fissures and cavities between the columns, announcing the shrinking of its mass during its induration, a circumstance which is never observed.

When therefore we consider the various phenomena connected with basaltic dykes, and more especially with columns of basalt; and when we reflect upon the analogy in composition, as well as in appearances, that holds between basalt and some kinds of lava; and, lastly, when we observe lava itself, under certain circumstances, assuming a columnar and truly basaltic aspect, we can, I think, scarcely ascribe the origin of this substance to any other source than that of fire, acting perhaps under peculiar circumstances, and frequently under some great pressure, derived probably from a superincumbent ocean.

IX.

Metallic Veins.

In several of my former lectures I have had occasion to advert to the existence of fissures, that disturb the continuity of the strata of the earth's surface, and that are filled with materials differing from those of the rocks they traverse. I now propose more exclusively to notice these subjects, examining in detail the geology of metallic veins, or, as in this country they are often technically termed, lodes or courses.

In respect to the origin of these important deposites of our mineral and metallic treasures, it deserves, in the first place, to be remarked, that they almost always bear evidence of having been formed and filled subsequent to the production of the rocks in which they occur; and that it is only in a very few instances that the utmost stretch of theory will permit us to consider a vein as a mere accidental irregularity, coeval with its including strata, or contemporaneous with the rocks which it traverses.

To give an idea, therefore, of the nature of a vein, it has been common to compare it to a large crack, or irregular fissure, having something of the appearance, in many instances, of those which form in clay or mud, during its gradual shrinking and desiccation, and then to conceive it subsequently filled with those various substances which occur in it, and which are consequently of a nature totally dissimilar to the materials that form the sides or walls of the veins.

Such, indeed, is a sufficiently correct representation of the circumstances that attend many metallic veins. There is a mere fissure in the rock, not interfering with the parallelism of its strata, and formed, as it were, by some gradual and quiet operation. But, in other cases, the appearance of a vein is wholly different, and announces the result of some much more violent and sudden operations. The parallelism of the strata *is* disturbed, and that greatly; the walls, instead of being similar, are evidently displaced, and the adjacent substances irregularly heaved, or thrown into new postures, by some great convulsion which caused the fissure in question. This may have been derived from volcanic explosions, or earthquakes, or from some other cause, by which the strata may have been ruptured, leaving, in some instances, empty fissures, subsequently receiving their contents, and at others filling the veins with lapideous or metallic bodies.

The notion of cracks and fissures existing in the strata, and afterwards filled with the various substances constituting the vein, and flowing into it from above, may serve to give an idea of the Wernerian theory, applicable to this intricate part of geology; and it ascribes the occasional irregularities or dislocations of the strata, to the falling in, or slipping down, of one portion of the rock, soon after, or during the shrinking that occasioned the aperture. It is then supposed that various solutions flowed into these empty chasms, and that, crystallizing quietly and slowly, they lined them successively with the various bodies which now form the contents of the vein.

I need scarcely say that this theory at its very outset puts all the principles of chemical philosophy at defiance; attributing as it does an universal solvent power to some imaginary liquid, more

powerful even than the alkahest of the alchemists—withdrawing that fluid at pleasure, and enabling it successively to perform the most discordant and opposite functions. Nor are we informed how it came to limit its depositions to the veins themselves; not even without overspreading the circumjacent strata, but without leaving any trace behind upon ground where it is supposed to have rested, infinitely more favourable to crystallization or deposition than the tortuous chasm to which its powers seem to have been nearly limited, or, indeed, entirely confined. The Neptunist has urged in favour of his theory, the occurrence of fossils, of fragments, and of pebbles, in veins, evidently derived from the superficial strata, and demonstrating them at some period to have been open from above, and such things do, although rarely, occur. Werner alludes to a vein filled with rolled pieces at Joachimsthal; to another in Dauphiny; and Mr. Gilbert found rounded pebbles cemented together by tin-stone in a vein of the Relistian Mine in Cornwall: all which proves that some pebbles may have occasionally fallen into veins, and that at a very remote date, without in any way demonstrating that the crystalline aggregates of veins are all of similar origin.

If we now advert to the Huttonian theory, we shall there see the appearance and phenomena of veins attributed to the injection of their contents from below in igneous fusion, an hypothesis of which the most one can say is, that it involves fewer absurdities, though not, perhaps, fewer difficulties, than the former—for there are facts to be observed in the direction of veins, in their action upon the neighbouring strata, in the arrangement or order of their contents, which entirely militate against the notion of this method of their production, and which leave us at an utter loss for any plausible explanation consistent with the known physical and chemical attributes of matter.

That all rocks are occasionally penetrated by veins, but that those which are metalliferous are limited to the older series, has been stated in our general enumeration of the contents of different strata. It has also been remarked that regular metalliferous veins most frequently take the direction of east and west,

or nearly so, and that those which cross them, or run nearly in the direction of north and south, are generally filled with other substances. I say generally, because there are several exceptions to the statement I have made, just as there are east and west veins destitute of the metals.

It is often imagined that veins are widest above, and that they gradually taper off and are lost at great depths in imperceptible filaments; but this is by no means the case; and hitherto I believe the actual termination of a vein, properly so called, has never been seen. Cross courses sometimes suddenly interrupt a vein, and its continuation cannot again be discovered; sometimes veins dwindle into thin filaments, or become so impoverished by diminution in their metallic contents, as not to justify the expense of the pursuit; but in other cases the continuation of the vein intercepted has been discovered, and the thin filaments or threads have in several instances been known to reunite, not merely into a profitable vein, but even into a large bunch of metal.

Veins generally pursue a straight line, or nearly so, and if they deviate from it, they reassume shortly their former regularity, their direction being downward, not perfectly perpendicular, but more or less inclined to the north or south. This inclination is called the underlie of the lode, and is very variable. Mr. Phillips, in his excellent practical account of the Cornish Mines, printed in the *Geological Transactions*, and again in his *Geology*, tells us that in Cornwall some of the veins only underlie a few inches from the perpendicular in a fathom, but that in others the underlie is a fathom, or even more in the same extent. When a vein pursues a steady and regular progress, the term *rake* is generally applied to it; but where it bulges out into irregular masses, and forms, as is sometimes the case, large horizontal beds of metal, the term *pipe vein* is often applied to it, or the bulge is called a *floor* of metal. Here also we may mention the different direction which different veins often take. In the mines of North Wales, in most of those of Cumberland and Derbyshire, in the great mines in Arkendale and Swaldale, in York-

shire, the veins of lead, like those of copper in Cornwall, are east and west; but, on the other hand, the lead and silver of Cornwall is north and south in many instances—lead in Cornwall, for instance, being chiefly found in north and south veins, and the smaller veins of Cumberland and the counties adjacent, traversing the strata in almost all directions. These are the exceptions to which I adverted, in alluding to the general east and west direction of veins.

In regard to *width*, metalliferous veins are extremely various, and their value is not always proportionate to their diameter. Some of the veins of Cornwall are from 30 to 40 feet wide, but less productive than when only 3 or 4 feet in width; and in some cases they shall be worth working, from their extreme richness, when not more than 2 to 4 inches wide; and in relation to this subject, the nature of the pervaded country must be taken into the account. In Cornwall, Mr. P. says, that if, on working in the course of a vein, the country is found to assume a greater hardness in a considerable degree, the vein generally becomes narrow.

In Derbyshire and in the North, the lead-veins in the limestone are remarkably affected by the shale, sandstone, and toadstone, and in some places entirely cut off; while in others they divide into very small ramifications, which in the limestone again unite into a large continuous vein.

In Mexico, they are upon a larger and more magnificent scale, proportionate as it would seem to the greater extent and elevation of the mountains of the New World. Humboldt adverts to veins containing silver ore from 60 to 90 feet wide.

In many of the richest metallic veins, the ore is separated from the walls of the rock by a coating of clay, probably the decomposed rock, which varies in thickness, but which sometimes is wanting upon one side. In other cases various sparry substances intervene, and in others the metal itself forms a close junction with the rock. But in these, as well as in other respects, the texture of a vein is so capricious, that any general description must be taken with many limitations and exceptions. This is more especially the case in respect to the contents of veins of

different depths which are liable to such diversities as to baffle all conjectures founded even upon extensive and careful experience.

In Cornwall, symptoms of metal rarely occur at a less depth than 30 fathoms, the upper part of the lode being full of clay, gravel, and the debris of the neighbouring country. If at that depth there occur a quantity of friable ferruginous clay of a yellow or red-brown colour, and provincially called *Gossan*, the proximity of tin or copper may be anticipated. But blende, iron pyrites, chlorite, quartz, and clay, may prevail for many fathoms without any more valuable products. Tin and copper are often found in the same vein, but the tin almost always precedes the copper; and in Cornwall many of the richest copper-mines are the continuations of tin-veins which had been imagined to be exhausted, or which had been given up, from their depth, before the great improvements in draining mines by steam-engines had arrived at their present excellence. Even in rich and productive veins, the valuable portion is seldom in such abundance as to leave by its removal a perfectly empty chasm; though this is sometimes the case, as in the Paris Mine in Anglesea, where an immense space or quarry indicates the extent of the removed treasures*—generally there is left a quantity of quartz, calcareous spar, fluor, iron pyrites or clays, usually termed *Deads*, and which often are in so far useful, that they serve to support the walls of the vein, and are a durable substitute for the timbers, with which, in very rich veins, they are obliged to support the impending rocks, and which often from its falling in gives rise to disastrous accidents. An instance of this kind is mentioned by Mr. Phillips as having occurred in Cornwall, in the copper-mine called Wheal Alfred, one of the veins of which was hollowed out for about 100 fathoms' deep, so as to form a very extensive chasm; and, notwithstanding great labour, skill, and expense had been bestowed, and the most substantial timber employed to keep apart the walls of the vein, many thousand tons came down in an instant.

Among the irregularities of veins, there is one, not of frequent

* The copper and tin-veins of Cornwall are generally much more irregular than the lead-mines of the north of England, and hence more difficult to work.

but occasional occurrence, and which throws great difficulty upon many of the theories of veins; the miner shall suddenly arrive at a piece of dead ground in the midst of the vein, leaving only a small connecting string of ore on each side, and sometimes extending many fathoms in length and depth. In these cases, the miner says that the vein, or lode, has taken horse. The disturbance of veins, by cross courses, furnishes not the least important part of their geological history, and as one metallic vein is sometimes intersected by another, showing them to be of different dates, so we find that cross-veins are usually of more recent date than those containing metallic ores, as is demonstrated by the manner in which they are cut through and transversed ; and both are, as I have already stated, of a posterior date to that of the traversed rocks, as is shewn by the division in the parallelism of its beds. When I have said that metalliferous veins, as far as I know in all parts of Europe, and even in the great mining district of America, affect an east and west direction, and that the north and south veins are not metalliferous, and of a later date than the others, I must again beg to observe, that this statement is merely meant to apply *generally*, and that in England and elsewhere it is open to frequent exceptions, as in regard to the veins containing lead and antimony in Cornwall, and also, even in some instances, tin has been found in such a cross-vein.

In a few cases the cross course is rather advantageous than otherwise to the interests of the mine: a poor vein often becomes very productive near the cross course, and sometimes they prevent the water of the neighbouring country from troubling a mine ; but the various interruptions which are occasioned in the metalliferous vein are more commonly a source of great vexation and trouble to the miner, and though these disturbances are now much better understood than formerly, cases of great intricacy and difficulty frequently occur, which baffle the most skilful efforts of the scientific and experienced miner, and lead to incalculable expenses. Another way in which it is possible that a cross course may be of service is, by heaving the metallic vein, so as to bring it nearer the surface. This is well illustrated in Pryce's Section

of Pink Mine, where a tin-vein is intersected in its course by three gossans, and heaved each time, at first 22 fathoms, then 9 fathoms, and then about 2.

In the mines of Derbyshire, and in the lead-mines of the north, I have adverted to the modified size and contents of the metallic vein, depending upon the nature of the strata through which it passes, and especially to the influence of the grit and toadstone, in impoverishing or intersecting a vein large and productive in the limestone. In Cornwall, both the granite and slate are traversed by veins of tin and copper; and here a very curious question, both in its practical and theoretical relations, presents itself, namely, what changes does the vein suffer at the junction of the slate and granite? The mines of Cornwall enable us to answer this question, and it generally happens that the derangement suffered by the vein is very trifling, even where slate and granite alternate, as is often the case, in consequence of the veins of the latter penetrating the former rock; and in Huel Gorland, a vein passed between granite and slate, having one of its walls of one substance and the other of the other. Tin Croft Mine also offers some remarkable alternations of schist and granite, as well as some peculiarities in respect to the number, underlie, dimensions, and contents of its veins. There are here five copper veins, three of tin, and one mixed, in about a furlong of country, north and south. Of these, two only proceed in a straight line; one alters its direction repeatedly in a gradual approach to the perpendicular, and is intersected by two copper veins; one of these, the south vein, varies in width from one to six feet, and was rich in copper through the upper granite and slate, but became hard and poor upon re-entering the lower granite. Another vein varied from one to twelve feet in width, and running nearly perpendicular, sent off two other veins or offsets, becoming very poor at the point of their separation, but containing shoots of ore between them. Below the latter it became richer, and was worked to a depth of 125 fathoms from the surface; the first offset was a poor vein, but the second very abundant in copper pyrites; the sixth vein yielded a little tin; the seventh yielded copper and iron py-

rites; the eighth yielded tin and copper, sometimes mixed, and sometimes running side by side down the vein; and the ninth was extremely prolific in tin for a depth of 45 fathoms from the surface, when it became as poor, and filled with iron pyrites; but at a greater depth, where it traverses another mine, it has been found as rich in copper as it was near the surface in tin.

In vein No. 3, granite was found on one side, and slate on the other, and detached masses of granite and slate were found both in it and No. 2.; and frequently where the vein traversed granite, it contained fragments of slate; and where it passed through slate, there were found in it detached masses of granite.

The account of this mine will serve to give some idea of the intricacy, irregularity, and uncertainty in the disposition, number, and contents of veins; it also alone furnishes such a singular assemblage of contradictions to all received theories of veins, as to show their utter inadequacy, and the uselessness of bestowing further time upon the contradictory statements and empty pretensions of their inventors.

In the texture and hardness of the principal rocks traversed by these veins, namely, granite and slate, there is the greatest possible variety, but I am not aware that any concomitant effects upon the metallic vein have been proved. The harder the rock, of course the less profitable the vein, or rather the more expensive the operations of the miner. In slate alone Mr. Phillips mentions the expense of sinking a shaft to vary from *5l.* to *55l.* per fathom; and occasionally a bed or channel of some extremely hard substance almost arrests the entire progress of the work; but this occurrence is not frequent.

The means of arriving at a vein, or working a mine, are varied according to the nature of the rock or country which it traverses, and are dependent upon an infinite variety of adventitious circumstances frequently connected with those under which the vein was originally discovered, and which discovery is sometimes the result of accident, such as by making roads, cutting ditches, or draining land; or sometimes it is arrived at by the discovery of fragments or pebbles of ore in the beds of rivers, or in alluvial

F 2

soil, through which streams formerly appear to have passed. Thus the ancient mode of shoding for tin consisted in tracing certain stones containing tin, to the vein whence they had been detached. Sometimes the course of a vein may be learned by the nature of the fragments and stones upon the surface, more especially by their ochreous tints. A knowledge, too, of the substances which, in different countries, usually accompany the ore of metal forming its *gangue*, or *matrix*, is often of much importance in these inquiries. In Cornwall, quartz is most abundant; in Derbyshire, carbonate of lime and fluor; in Yorkshire, cawk, or sulphate of baryta; and in Cumberland, cawk and fluor.

Sometimes the springs in the vicinity of metallic veins are so tainted as to lead to their discovery. Of this a singular instance occurred some years ago at Dolgelly, where the part in the neighbourhood of the vein was so impregnated by the metallic soil, as to leave copper in its ashes when burned. When this was ascertained, the injured vegetation guided to the vein. By the retention, therefore, of these contaminated waters in the soil near the vein, it may become unfit for vegetation, and thus the sterility of certain patches of land may indicate the existence of metallic bodies in the district.

There are no class of persons more curiously superstitious than miners, and hence a variety of omens, connected with the interference of agents from the spiritual world, are among the items of their creed. Sometimes while underground they fancy they hear another pick at work, announcing the presence of a little man, or pixey-knocker, in some neighbouring cavern, and the consequent vicinity of a good course of ore. Sometimes even the divining rod is resorted to, and sometimes it is said that flames of light, dancing about a mining district, have suddenly perched upon the vein, and there rested for a time, and disappeared, a circumstance, this, not improbably connected with electricity, and referrible perhaps to the good conducting power of the vein, either from the ore or water which it contains; indeed, almost all rich veins abound in water, which gushes from various parts, often of very different temperatures; the warmer it is the more favour-

able to the production of ore. Hence, upon deep and rich mines, several steam-engines of large dimensions are requisite to carry away these subterranean torrents.

In former times, when a vein of metal was discovered, it was worked to a certain depth, and then often abandoned, in consequence of the insufficiency of the pumps to carry off the water, or of the expense incurred in their erection and working. In certain situations, however, it was found that this water ran off at lower levels, and that in most instances it might be carried away by an underground tunnel, commencing at the foot of the hill, penetrating to the vein, and thus forming a communication with the working of the mine and a neighbouring valley. These tunnels are now called adits, and when it is resolved to try a vein, one of these underground passages, about 6 feet high, and $2\frac{1}{2}$ wide, is begun at the bottom of the neighbouring valley, and driven up to the vein, for the purpose of carrying off the water; or if a mine has an engine upon it to raise the water from a greater depth than that of the entrance of the adit, the engine then, instead of having to lift the water to the surface, throws it off with diminished labour at the adit. In general, adits are nearly horizontal, for although a declivity would accelerate the drainage, it would, in a passage of any length, be attended by the disadvantage of entering the mine at less depth. The importance of draining mines by adits has led to some gigantic undertakings of this kind. The great Cornish adit commences in a valley above Carnon, near the sea, and branches off in its course in several directions to about 50 mines in the parish of Gwennap. Most of these are much below its level, and the water is raised into it by numerous steam-engines. The entire length of this adit, with its various branches, is about 26,000 fathoms, or nearly 30 miles; but the greatest length of any one branch from the mouth is at Cardrew Mine, and is 4800 fathoms = $5\frac{1}{2}$ miles; its greatest depth is at Wheel Hope = 70 fathoms. It empties itself into Falmouth Harbour.

The adit of the Duke of Bridgewater's collieries at Worsley, is about 30 miles long, and navigable. Another great work of this

kind is the tunnel of the Tavistock Canal, through Morwel Down, joining the River Tavy with the Tamer, and nearly 2 miles long underground, at a depth in many places of 130 yards from the surface. The section of this hill* shows the beds or dykes of quartz and porphyritic rock which traverse the killas or slate, of which the bulk of the hill is formed, and the direction of which is nearly parallel, ranging east and west. It also shows the differing inclination or dip of the metallic veins.

Another great adit is the Nantforce level, near Alston Moor, driving at the expense of the commissioners of the Greenwich Hospital estates; it is now about 2 miles long, and will drain many valuable mines.

Where an adit is of any length, it is obvious that the air would become stagnant in it, and hence the necessity of fresh supplies, derived from perpendicular openings, which are called *shafts*, and which also serve for the removal of the produce, and the more direct access of the miners to their work. From these shafts *levels* or *galleries* are excavated, and driven in various directions, either for exploring or removing the contents of the vein.

The states in which metals are found in veins, or the combinations which they present, are extremely various. In a few cases they occur in the metallic state, nearly or quite pure, and these are termed native; but generally the qualities of the metal are disguised by some mineralizer, such as sulphur, arsenic, or oxygen, and these ores are again variously modified by the presence of other extraneous substances, leaving much to the industry and skill of the metallurgist, before the metal can be *reduced* or brought by various chemical processes to its pure form, to the state in which it is required for the purposes of the manufactures and of the arts.

[To be continued.]

* See Mr. Taylor's paper in the *Geological Transactions*.

Art. VII.—*On the Air contained in River and Canal Water.* *By* Andrew Ure, M.D., F.R.S. *&c.*

[Communicated by the Author.]

Having had occasion lately to submit specimens of these waters to a careful analysis, my first object was to determine the quantity and nature of the aëriform contents. For this purpose I took a glass globe capable of holding about 18000 grains of distilled water, and filling it to the surface of the orifice with the given water, I forced into it a well-fitted elastic cork, through which there passed tightly the end of a glass tube, about one-fifteenth of an inch diameter in the bore. This tube, which was of the swan-neck form, and a foot in length, plunged at its other open end into the mercury of a pneumatic trough. On pressing the cork into the mouth of the globe, the water rushes into the tube and fills it throughout. Thus no air is left in the apparatus, to complicate the result of the experiment.

A graduated glass tube, filled with mercury, being inverted in the trough over the hooked end of the tube, heat was slowly applied to the globe by a charcoal chauffer. After some time the water began to boil, and was kept in ebullition as long as any aëriform matter was extricated. The following table exhibits the aëriform products from 18000 grain measures of water.

	Grains measure.
Canal-water (in winter)	480
Filtered river-water drawn in the city of Glasgow from the pipes of the Cranstonhill Water Company	454
Filtered river-water from the pipes of the Glasgow Water-Company	450
Water taken directly from the River Clyde, somewhat swollen by winter rains	505

These numbers being compared with the total bulk of water examined, give the following fractional proportions of air contained.

Canal-water $\frac{1}{37\cdot5}$, Cranstonhill pipe-water, $\frac{1}{39\cdot65}$, Glasgow Water-Company's pipes, $\frac{1}{40}$, open river-water, $\frac{1}{35\cdot64}$.

Hence we see that the action of pumping expels a portion of

air from the river-water. The gaseous matter obtained from the first three waters consisted of $\frac{1}{10}$ carbonic acid gas, and $\frac{9}{10}$ atmospheric air. That from the open river-water contained only $\frac{1}{20}$ of carbonic acid. Thus it would appear, that some carbonic acid is introduced into the waters of the pipes, from the decomposing vegetable matter contained in the sand banks on the sides of the river through which it is filtered into the reservoirs. A similar decomposition will account for the similar proportion of carbonic acid gas in the canal-water.

The above waters, when submitted to analysis, had a temperature of about 55° Fahr.

By using the very cheap and simple apparatus here described, the gaseous part of the analysis becomes a very easy problem, enabling us to ascertain with precision the amount of gaseous matter separable at a boiling temperature. Whether the whole aëriform contents be thus obtained, I shall not pretend to decide.

Art. VIII. *Improvements in the Solution of Equations by Continued Fractions. By* W. G. Horner, Esq.

[Communicated by the Author.]

1. The artifices detailed in the concluding sections (81 *et seq.*) of Lagrange's *Resolution des Eqq. Numm.* redeem that author from a heavy portion of the charge of difficulty which lies against his system. Yet no part of the work seems to have been written with so little attention; and it is the purpose of these remarks, to point out several improvements, both of a theoretical and a practical nature, which have occurred to the writer.

2. Having premised that $\frac{\pi}{\pi'}$, $\frac{\varrho}{\varrho'}$ being the latest approximations to the value of x, and $t^n - at^{n-1} + bt^{n-2} - \ldots\ldots = 0$ being the consequent transformed equation in following his well-known process, t whose accurate value is $\frac{\pi' x - \pi}{\varrho - \varrho' x}$ may be reduced to $\pm \frac{1}{\varrho'^2 \left(\frac{\varrho}{\varrho'} - x \right)} - \frac{\pi'}{\varrho'}$, the upper sign applying when $\frac{\varrho}{\varrho'} > x$

and the lower on the contrary supposition; Lagrange proceeds to prove (1) that, in a sufficiently advanced stage of the transformation, t will be contained between the limits $a + \frac{(n-1)\pi'}{\varrho'} + \frac{1}{2}$ and $a + \frac{(n-1)\pi'}{\varrho'} - \frac{1}{2}$; and (2) that, a being accurately $= \pm \frac{dX}{\varrho'^2 X dx} - \frac{n\pi'}{\varrho'}$, $a + \frac{(n-1)\pi'}{\varrho'}$ may be represented by $\pm \frac{dX}{\varrho'^2 X dx} - \frac{\pi'}{\rho'}$. From the period at which these conclusions become correct, the affirmative root of every subsequent equation is therefore truly determinable in the nearest integers, either from the transformed equation, or immediately from the original one, and in either case *without any trial.*

3. Now no satisfactory reason appears for putting t as a function of $\frac{\pi'}{\varrho'}$. On the contrary, we should naturally expect $\frac{\pi}{\varrho}$ to be preferred, as being a closer approximation to that to which $\frac{\pi'}{\rho'}$ is itself an approximation [see Art. 8 below]; a circumstance that claims attention, both at the commencement of this stage of the process, as likely to introduce it *earlier* and with more steadiness of the first steps, and at the point where we choose to stop, as enabling us more accurately to estimate the *entire* root of the concluding equation.

4. Accordingly, treating t as a multiple of $\frac{\pi}{\varrho}$, we find its value to be $\pm \left(\frac{1}{\varrho'^2 \left(\frac{\rho}{\varrho'} - x \right)} - \frac{1}{\varrho\varrho'} \right) - \frac{\pi}{\varrho}$; and so of the inferior roots t', t'', &c., by changing x for x', x'', &c. Now, if x is the principal root of the original equation*, and $\frac{\rho}{\rho'}$, a distinct ap-

* The root toward which the approximation is directed necessarily becomes the principal root, as soon as a *distinct* approximation is attained. [Lagrange, §. 19.]

proximate value of x, the quantities $\frac{\rho}{\rho'} - x'$, $\frac{\varrho}{\varrho'} - x''$, &c., will all be affirmative. Consequently $\frac{1}{\varrho'^2\left(\frac{\varrho}{\varrho'}-x'\right)} - \frac{1}{\rho\rho'}$, &c., will be affirmative and $< \frac{1}{\varrho'^2\left(\frac{\varrho}{\varrho'}-x'\right)}$, &c. But, as Lagrange shews, the sum of the $n-1$ quantities $\frac{1}{\varrho'^2\left(\frac{\varrho}{\varrho'}-x'\right)}$, &c., at a certain stage of advance becomes $< \frac{1}{2}$. Wherefore the sum of the $n-1$ quantities $\frac{1}{\varrho'^2\left(\frac{\varrho}{\varrho'}-x'\right)} - \frac{1}{\varrho\varrho'}$, &c., will be $< \frac{1}{2}$ still earlier. So that $a = t + t' + t'' + \ldots$ is $= t - \frac{(n-1)\pi}{\varrho}$ more nearly than $t - \frac{(n-1)\pi'}{\rho'}$; and therefore $t = a + \frac{(n-1)\pi}{\varrho}$ more nearly than $a + \frac{(n-1)\pi'}{\varrho'}$.

5. Again, the sum of the n quantities $\frac{1}{\frac{\varrho}{\varrho'} - x} + \frac{1}{\frac{\varrho}{\varrho'} - x'} + \ldots$ $= \frac{dX}{Xdx}$, if after differentiation x be made $= \frac{\rho}{\varrho'}$. Hence a, or $t + t' + t'' \ldots$, is $= \pm\left(\frac{dX}{\varrho'^2 Xdx} - \frac{n}{\varrho\varrho'}\right) - \frac{\pi}{\rho}$. In other terms, if $R' = \frac{A\varrho^{n-1} - 2B\rho^{n-2}\varrho' + 3C\varrho^{n-3}\varrho'^2 - \ldots\ldots\ldots \pm nL\varrho'^{n-1}}{\varrho^n - A\varrho^{n-1}\varrho' + B\varrho^{n-2}\varrho'^2 - \ldots\ldots\ldots \mp L\varrho'^n}$, then will $t = \frac{\pm R' - \pi}{\varrho}$ more nearly than to $\frac{\pm R - \pi'}{\varrho'}$ as given by Lagrange.

6. One may easily, and with some additional advantage, arrive at the same conclusion, by other considerations, quite detached from our author's peculiar notation and train of argument; *viz.*, by

reflecting upon the ratios of *increasing inequality* among the *affirmative* roots, and of *decreasing inequality* among the *negative* roots, which necessarily attend his process of first diminishing the roots, and then the reciprocals of the remainders, and so on indefinitely, by subtraction of affirmative integers. For, if the roots of any equation in a series so conducted be x, x', x'', &c., beginning with the greatest; and those of the next be y, y', y'', &c., beginning with the least; and p be the nearest integer less than one of the values of x; then is $y = \frac{1}{x-p}$, $y' = \frac{1}{x'-p}$, $y'' = \frac{1}{x''-p}$, &c., and $\therefore$

$\frac{y'}{y} = \frac{x-p}{x'-p}$, $\frac{y''}{y} = \frac{x-p}{x''-p}$, &c. Now $\frac{x-p}{x'-p} = \frac{x}{x'} + \frac{p(x-x')}{x'(x'-p)}$, which is $> \frac{x}{x'}$, if y' is affirmative; for in that case p and $x - x'$ are affirmative (*hyp.*); but $< \frac{x}{x'}$, if y' is negative, for the reverse reason.

7. Hence it follows, (1) that whatever proximity exists among the affirmative roots of the given equation, we shall at length arrive at a transformee, whose only affirmative root > 1 is that toward which the approximation is directed; unless that be a duplicate root, a case for which it is easy to modify our reasoning: (2) that, of the next transformee, all the roots but one are *negative;* and those of the next to this, all but one, both *negative and fractional,* that is < 1 abstracting the sign: (3) that, from this point, each of the negative roots, that is, every root of the equation but one, consists of one and the same chain of fractions; and that, the same which has been appended to the affirmative root during the interval, but taken in the contrary order; for, to each of the previous negative fractions one and the same negative integer is added, *viz.*, the same by which, taken affirmatively, the principal root is diminished; and in taking the reciprocals, this integer becomes a denominator common to all the negative roots; so that if the root toward which we tend is $e + \frac{1}{f+} \cdots \frac{1}{m+}\frac{1}{r+}\frac{1}{s}$, as far as already determined, the transformee at which we have

arrived will have $n - 1$ negative roots, each commencing with $s + \frac{1}{r+} \frac{1}{m+} \frac{1}{\&c.}$ *.

8. Now a little reflexion on the mode in which a continued fraction is turned into a series of converging fractions, will convince us, that if $e + \frac{1}{f+} \dots \frac{1}{m+} \frac{1}{r} = \frac{\pi}{\pi'}$, and $e + \frac{1}{f+} \dots \frac{1}{m+} \frac{1}{r+} \frac{1}{s} = \frac{\varrho}{\varrho'}$, then is $\frac{1}{s+} \frac{1}{r+} \frac{1}{m+} \dots \frac{1}{f} = \frac{\pi'}{\varrho'}$, and $\frac{1}{s+} \frac{1}{r+} \frac{1}{m} + \dots \frac{1}{f+} \frac{1}{e} = \frac{\pi}{\varrho}$.

[Or the reader may consult the concluding paragraphs of an Essay by our Author on Numerical Analysis, in *Journal de l'Ecole Polytechnique*, Vol. II., translated in Volume I. of *Leybourne's Math. Rep.*]

9. The value of t is $\therefore$ nearly $a + \frac{(n-1)\pi'}{\varrho'}$, but more accurately $a + \frac{(n-1)\pi}{\varrho}$. The distinction is of importance at the points indicated in Art. 3; but at the intermediate points less rigour is wanted, and it will be sufficient to sum a few terms of the continued fraction: thus $t > [a + \frac{n-1}{s} + \frac{1}{r} =]\ a + \frac{(n-1)r}{rs+1}$ and $< [a + \frac{n-1}{s} + \frac{1}{r} + \frac{1}{m} =]\ a + \frac{(n-1)(mr+1)}{m + (mr+1)s}$.

10. This view of the subject has not only the advantage of being intelligible, independently of Lagrange's connected and peculiar chain of deduction, but of doubling, to say the least, every facility which he contemplated as flowing from the artifice in question. He has nowhere employed it, as far as I can discover, but as a means of ascertaining the *integral* portion of the root of the transformed equation: it is *now* manifest, that from the instant when *this* use of it begins, up to that at which we stop the calculation,

* The influence of imaginary quantities will be discussed in the next portion of this tract.

every link of the continued fraction has a twofold effect in correcting the root; first, as a direct portion of x, and again in reverse order as a portion of the ultimate t. To instance in Newton's example, $x^3-2x = 5$, where Lagrange finds $x = 2 + \frac{1}{10+}$ $\frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \frac{1}{1} + \frac{1}{3} + \frac{1}{1} + \frac{1}{1} + \frac{1}{12}$, I propose, by using the same data which furnished the last denominator 12, to double the extent of the fraction; which can certainly be done, because the artifice in question applies from the very outset. The equation in t must have been $541t^3 - 6057t^2 - 7283t - 2084$ $\therefore a = \frac{6057}{541}$; and $\frac{\pi}{\pi'} = \frac{731}{349}$, $\frac{\rho}{\rho'} = \frac{1307}{624}$. Consequently

$$t = \frac{6057}{541} + \frac{1462}{1307} = 12 + \frac{106}{541} + \frac{155}{1307} = 12\,\frac{222397}{707087} \text{ nearly.}$$

The continued fraction being taken out to the required extent gives

$$t = 12 + \frac{1}{3} + \frac{1}{5} + \frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \frac{1}{1} + \frac{1}{6} + \frac{1}{9},$$

with some uncertainty about the last denominator 9. The root x is therefore $= 2 + \frac{1}{10} + \frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \frac{1}{1} + \frac{1}{3} +$ $\frac{1}{1} + \frac{1}{1} + \frac{1}{12} + \frac{1}{3} + \frac{1}{5} + \frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \frac{1}{1} +$ $\frac{1}{6} + \frac{1}{9} \pm$ &c.

11. If we turn to quadratic formulæ, of which so much use is made in the indeterminate analysis, the benefit accruing from the improved statement of things becomes strikingly apparent. The evolution of these formulæ in continued fractions, the reader is aware, is characterized by periodical returns of the same circle of denominators. The immediate cause is, the periodical return of the same circle of transformees. Now the distinctive mark of these periodical equations is the having one root $+$, and the other $-$, at the same time that one is > 1, and the other < 1, abstracting the negative sign. Consequently they are in the very circumstances

described in the conclusion of Art. 7, so that *the self-same operation gives both the roots accurately;* the negative root consisting of the same period of denominators as the positive, but taken in retrogradation.

12. This property of periodic equations, which saves half the trouble of solving every-quadratic, has been totally overlooked by writers on Continued Fractions. For instance, in the Additions to Euler's Algebra (Art. 40,) Lagrange determines the roots of $9x^2 - 118x + 378 = 0$ to be $7 + \left(\frac{1}{1} + \frac{1}{1} + \frac{1}{5} + \frac{1}{3} + \frac{1}{2} + \frac{1}{1} + \right)^\infty$, and $5 + \frac{1}{1} + \frac{1}{1} + \left(\frac{1}{3} + \frac{1}{5} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \frac{1}{2} + \right)^\infty$. Each root occupies nearly a page of separate calculation. Now, if the former root be correct, the latter ought to be $= 7 - \left(1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{5} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \right)^\infty$.

But, by a well-known process, $7 - \left(1 + \frac{1}{2}\right) = 6 - \frac{1}{2} = 5 + \frac{1}{1} + \frac{1}{1}$, which reduces the expression to that determined by Lagrange.

13. The formula $x^2 - N = 0$, having roots of contrary signs, both greater or both less than 1, produces periodical transformees from the very first. Wherefore one root being $R + \left(\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \ldots \frac{1}{n} + \frac{1}{p} + \frac{1}{r} + \right)^\infty$, the other will be $R - r - \left(\frac{1}{p} + \frac{1}{n} + \ldots \frac{1}{c} + \frac{1}{b} + \frac{1}{a} + \frac{1}{r} + \right)^\infty$.

Now one of these is $= \sqrt{N}$, and the other $- \sqrt{N}$; that is, they are identical, abstracting the sign. Wherefore,

(1st.) $R = r - R \therefore r = 2R$; or, the last denominator in every period of a square root is double the integral part of the root.

(2dly.) $a = p$, $b = n$ &c.; or every square root is of the reciprocating form $R + \left(\frac{1}{a+}\frac{1}{b+}\frac{1}{c} + \ldots \frac{1}{c+}\frac{1}{b+}\frac{1}{a+}\frac{1}{2R+}\right)^{\infty}$.

The first of these two theorems is well known, but has never, I believe, been so simply demonstrated. The second, I believe, is new. The practical facilities connected with it will be pointed out hereafter.

Art. IX.—*On the Difference in the Length of the Human Fingers.* *By* Thomas M'Keever, M. D.

[Communicated by the Author.]

The exquisite mechanism and design displayed in the formation of the human hand, have afforded to the anatomist and physiologist, in every age, an ample subject for wonder and for admiration. Consisting of a great variety of complicated organs, such as bones, muscles, ligaments, &c., the different parts are yet so compactly and so commodiously arranged, as to enable the individual to perform, with a degree of rapidity truly astonishing, the most delicate, as well as the most powerful and varied movements. Hence the assertion of Anaxagoras can hardly excite surprise;—"that man owes all his wisdom, knowledge, and superiority over other animals, to the use of his hands *."

But, notwithstanding the minute attention that has been paid to the structure of this part of our frame, there is still, it must be admitted, one point that requires elucidation, and of which indeed I am not aware that any explanation of a satisfactory nature has been offered, namely, why the several fingers should differ so materially in their respective lengths?—Would they not have been just as capable of accomplishing the same variety of purposes, were they all constructed (in this respect) after a similar manner.

* Aristotle terms the human hand "*The organ of all organs.*"

The following suggestion is offered, more with the view of inviting discussion, than as a comp[illegible]ctory solution of this [illegible]ifficulty. When we inspect the hand in its ex[illegible] condition, the whole may be considered as of a triangular form, the base being placed at the carpus, or wrist, while the apex is formed by the extremities of the fingers. On the forepart of the base, or palm, as it is termed, we observe two eminences, with an intermediate depression; one placed externally, or towards the radial side, forming what is called the ball of the thumb, and consists of a variety of small muscles, which it would be here superfluous to enumerate, serving to flex, to abduct, and approximate to the other fingers, this member: the internal or lesser eminence is formed of corresponding muscles for the little finger, while the central depression serves for the transmission of the great mass of flexor tendons in their passage forwards to the several phalanges. Now when we close the hand, as in the act of prehension, we find that the extremities of the several fingers adapt themselves with singular precision to the irregular surface here described: the index and middle fingers resting on the eminence formed by the muscles of the thumb: the ring-finger lodges itself in the central depression, while the little finger is accurately sustained by the lesser projection. Thus an equable support is furnished to the four lesser fingers, and the hand acquires a degree of steadiness and an extent of power which it could not well have attained by any other arrangement.

With regard to the thumb, to which Albinus has given the appropriate appellation of a second hand, "*Manus parva majori adjutrix* *," it is merely necessary to observe, that from its great size and strength it is admirably fitted for counteracting the other fingers when brought into opposition to them, as in grasping a spherical body. It is obvious, that if it were formed equally slender with the other fingers (having to act with the force of $1 = 4$), its power as an opponent must have been materially lessened. The presence of the thumb also enables us to use the hand as a

* *De Sceleto*, p. 465.

kind of forceps, hence those animals in whom this member is absent, as the squirrel, rat [illegible], &c., require the concurrence of both hands [illegible] to hold any moveable object *.

I cannot conclude this short paper without briefly adverting to the close analogy that is found to prevail between the structure of the human hand and corresponding parts in the lower animals. Thus the fins of the whale have nearly the same number of bones, and are of a similar form with those organs, although the two parts in the living animal are so exceedingly unlike †. In the turtle, there is even the resemblance of a thumb: the bat possesses five fingers, the metacarpal bones, and the phalanges of the four which succeed the thumb, being excessively elongated, so as to allow an extensive surface for the attachment of the membrane that serves this animal as a wing. The bones of the fins in the seal are also of an analogous structure. Lastly, the forefoot of the lion has the same bones, and same number of claws, as the human fingers.

There also appears to exist a regular gradation in the number of the fingers. Thus in MAN, *simiæ*, and *lemurs*, we have five (the thumb being separate) ‡: the elephant §, kangaroo, bear, lizard, and dog, have also five, but no separate thumb: the hippopotamus and hog have four; the tapir and rhinoceros three; the deer, cow, camel, and camelopard two; while the *solipeda*, as the horse and the ass, possess but one perfect finger.

These facts lead to one simple obvious conclusion: "that all animated beings in this world come from the same all-powerful hand, and belong to the same general scheme of creation."

Dublin, *March* 1*st*, 1826.

* Only MAN, *Apes*, and *Lemurs*, have the thumb separate, and capable of being opposed to the other fingers.—See Cuvier's *Comp. Anat.* vol. i.

† See Sir E. Home's *Lect. on Comp. Anat.* vol. i.

‡ In the Simiæ, the thumb is small, short, and weak, and the other fingers elongated and slender. They cannot move them separately, having no proper flexor or extensor muscles.—See Cuvier's *Comp. Anat.* vol. ii.

§ The Elephant has five perfect toes, but the whole five are almost entirely concealed under the thick skin which covers the foot.—Cuvier's *Comp. Anat.* vol. ii.

Art. X.—*On the Oscillations of the Barometer.* By J. F. Daniell, Esq. F.R.S.

In a former Essay upon the Constitution of the Atmosphere*, I endeavoured to elucidate the intricate phenomena of this department of nature, by synthetically constructing an hypothetical atmosphere upon the basis of the known laws of aëriform fluids. By gradually proposing each condition, and singly tracing its effects, I attempted to simplify the consideration of their compound relations; and I hoped to be able to shew that the principles derived from such an investigation would be sufficient to resolve all the problems of Meteorological Science. The progressive steps of this hypothesis led to the establishment of two great currents in the atmosphere, from either pole to the equator, on the surface of the globe; and back again from the equator to the poles, in the upper regions of the air. By following up the same train of investigation, I endeavoured to prove that the various oscillations of the barometer might be satisfactorily explained by interruptions of the regularity of this primary circulation; and I succeeded, I believe, in shewing that the variations in the aqueous part of the atmosphere, and the heat evolved and absorbed by its precipitation and evaporation, were sufficient to account for the greater interruptions. In another Essay I referred the minor horary movements of the mercurial column to the hourly variations of temperature acting upon the same currents, and I was led to anticipate that these movements, which had been observed to decrease from the equator towards the poles, would, beyond a certain latitude, be found to assume a contrary direction. This conjecture was in a great measure verified by a comparison of the observations made in the first two Arctic Expeditions, under the command of Captain Parry; and has since been confirmed by the more accurate register kept for this express

* See *Meteorological Essays*, by J. F. Daniell, F.R.S., published by Underwood.

purpose during the third; the particulars of which will be hereafter amply detailed.

Amongst the phenomena for which I endeavoured to account in my first Essay, I slightly alluded to the coincidence which was known often to occur in the movements of barometers situated at great distances from each other; and, mentioning the observation that this unison of action extends further in the direction of the latitude than in that of the longitude, I remarked that the fact confirmed the theory: for, as the grand currents of the atmosphere flow nearly in the direction of the meridians, any irregularity in their courses would most readily be propagated in the same line. Further consideration convinced me that this argument should have been greatly extended, and I perceived that a strict adherence to the legitimate conclusions of the hypothesis would establish, not only a partial and frequent coincidence of the aërial undulations in different latitudes, but a wide-extending and constant agreement. The want of combination in the meteorological observers of the present day made me despair of being able to bring the idea to the test of sufficient experiments, till accident threw in my way a register of inestimable value.

My friend Mr. Howard put into my hands, and obliged me with the loan of, some of the volumes of the Ephemerides of the Meteorological Society of the Palatinate: a work which, if it had been continued with its original spirit to the present time, would probably have left little to be desired in the way of observation; and which, even in its present state, would be found, by the diligent inquirer, to contain more *data* for a correct history of European weather than all other works upon the same subject taken together. During a tour which I made last year in Germany, I succeeded in obtaining a complete copy of these Transactions, from their commencement, in 1781, to their termination, in 1792. As this record is very little known in this country, and in its complete state very scarce, I shall be excused for giving a short account of its origin, and that of a society which might, undoubtedly, afford the most perfect model of a similar institution at the present day for promoting the Science of Meteorology. I

shall hereafter probably, if time should allow me to complete the task which I have commenced, draw up a Memoir upon the climate of Europe founded upon these careful documents. The labour will not be trifling, but cannot be thrown away in a case where such full reliance can be placed upon the experimental basis of the inductions.

The Meteorological Society of the Palatinate was established in the year 1780, under the auspices of the Elector Charles Theodore, who not only gave it the support of his public patronage, but entered with spirit and ability into its pursuits, and furnished it with the means of defraying the expense of instruments of the best construction, which were gratuitously distributed to all parts of Europe, and even to America. One of the first acts of the Association was, to write to all the principal Universities, Scientific Academies, and Colleges, soliciting their co-operation, and offering to present them with all the necessary instruments properly verified by standards, and free of expense. The offer was immediately accepted by thirty societies; and the list of distinguished men who undertook to make the observations shews the importance which was attached to the plan, and the zeal with which it was promoted in every part of the Continent. Amongst those who, for the good of science, undertook and executed this daily drudgery, we find the names of Hemmer, Weis, Planer, Senebier, Bugge, Van Swinden, König, Cotte, Egel, Pictet, Toaldo, and Euler. The Secretary Hemmer appears to have been indefatigable in his exertions to perfect this truly princely plan of operations; and, even now, but little could be added to the precautions taken in the preparation of the instruments which he describes, or to the ample instructions for their use, which he transmitted with them. Some idea may be formed of the comprehensive scale of the register, when it is known that it contains observations, three times in the day, of the barometer, thermometer in the shade and in the sun, hygrometer, magnetic-needle, direction and force of the wind, quantity of rain and of evaporation, the height of any neighbouring water, the changes of the moon, the appearance of the sky, and the occurrence of

meteors and of the Aurora Borealis. To these must be added, in some places, observations upon the electrical state of the atmosphere, upon the progress of vegetation, the prevalence of disease, changes of population, and migration of animals. The field of observation extended from the Ural Mountains in the east, to Cambridge in the United States in the west; and from Greenland and Norway in the north, to Rome in the south. This range included also stations upon three high mountains in Bavaria, and upon the summit of St. Gothard. The observations of each year are summed up, and compared with those which precede, in copious and most laborious tables of mean and extreme results; and many very interesting essays upon various branches of Meteorology are interspersed throughout the volumes. Unfortunately for science, the Secretary Hemmer died in the month of May, 1790, and from that time the Society appears to have languished, and finally to have become extinct amidst the troubles and the wars of the French Revolution. Would that another Hemmer could be found in this age to direct the uncombined efforts of meteorologists to one common purpose! And would that the scientific men of the present day, laying aside all petty and degrading jealousies, might see the advantage of uniting in a system such labours as lose the greatest part of their value from wanting unity of purpose!

Amongst other valuable suggestions, in these volumes, upon the proper uses of meteorological observations, I have found the first exemplification of the method of representing the oscillations of the barometer by a curved line upon a scale—a method which I think will appear, from the subsequent part of this paper, to be of the utmost consequence in connecting detached observations, and exhibiting their mutual relations. The instances of this application in the volumes before me are very few, and for very short intervals; but it has been employed, upon a small scale, to shew the accordance of great changes of the mercurial column at distant points. It is by an extension of this plan that I shall now proceed to shew, that, within certain limits, the movements of the barometer coincide by some general law over large

portions of the surface of the globe. I shall endeavour to trace, as far as the observations will allow, the limits of this coincidence, the particular direction in which it occurs, and the circumstances, if any, which modify its regularity. I shall speak of the facts first; and I shall afterwards endeavour to apply them in illustration of that theory by which, in reality, I was guided to their discovery. By this method of proceeding, whatever success I may be thought to obtain in establishing the latter, I shall at least have the satisfaction of fixing *data*, upon which others may found their own reasoning, but which must hereafter claim an explanation in every theory of the phenomena of the atmosphere.

Plates I. and II. represent the oscillations of the barometer at eighteen stations on the continent of Europe for one twelvemonth; they comprehend a space of nearly 18° of latitude, and 14° of longitude. The observations are laid down twice in the day, *viz.*, at 7 A. M., and 9 P. M., upon a scale of English inches, which, however, has been reduced in the engraving; each perpendicular division representing a tenth of an inch, and each horizontal division comprehending a day. The curves have been arranged in order from north to south, commencing with Spidberg, in Norway, and ending with Rome and Padua. In selecting the stations, I have endeavoured to confine one set, as much as possible, to the same meridian; while I have chosen a second nearly approaching one another in latitude, but differing widely in longitude.

Spidberg, the first station, is a small parish in Norway, situated between Christiana and Fredericshall, within a short distance of the North Sea on its western side, and of the Baltic on its eastern. The longitude of the place of observation, which was the church and residence of the minister, is represented in the Transactions as 9° 4′ E.; but there must be some mistake in this, as from the locality it cannot be less than 10° 50′ E. The latitude is 59° 30′ N., and the altitude above the level of the sea about 426 feet.

Stockholm, the second station, is situated in about the same degree of latitude, but nearly 8° apart in the longitude. The

place of observation was the Observatory close to the shore of the Baltic, above the surface of which it stands about 136 feet.

Copenhagen, the third station, is built upon the southern coast of the Categate, or entrance of the Baltic. The Royal Observatory, at which the register was kept, stands about 136 feet above the mean level of the sea; its latitude is 55° 41′ N., and its longitude 12° 40′ E. It is distant about 300 miles to the south-west of the preceding station.

Gottingen, the next in succession, is situated almost exactly upon the meridian from which we set out; its longitude being 9° 53′ E., and its latitude 51° 52′. It is about 290 miles distant from the North Sea, above the level of which it stands about 450 feet. The river Leine flows near it, and it is surrounded by moderate hills. The Hartz Mountains rise in the N. E., at a distance of not more than 15 miles.

Sagan, the fifth station, has been selected as corresponding with the preceding in latitude, *viz.*, 51° 42′ N., but being far removed in longitude, *viz.* 15° 27′ E. It is situated upon the Bober, and surrounded on all sides by extensive plains. The place of observation was raised about 60 feet above the level of the river.

Erfurt, the sixth station, again approaches the first meridian, but advances us to the south. Its longitude is 11° 23′ E., and its latitude 51° N. The surrounding country is open.

Brussels, the seventh station, is the most western point of our present comparison, and particularly remarkable, as we shall hereafter have occasion to observe, on account of its being the nearest to the Western Sea. It is situated in a very open country upon the banks of the small river Senne. The latitude is 50° 51′ N., the longitude 4° 28′ E. The barometer was placed about 175 feet above the level of the river.

Prague, the eighth station, carries us again more than 10° to the east; its longitude being 14° 50′ E., and its latitude 50° 5′ N. It is situated in a hilly country upon the banks of the Moldaw.

Mannheim, the ninth station, was the head-quarters of the

Meteorological Society; and here the observations, under the immediate superintendence of the Secretary Hemmer, were more varied and more complete than in any other place: on this account, as well as on that of its central situation, it furnishes the best standard of comparison for all the other observatories. All the particulars of its situation are most accurately described in the Transactions. It is placed in a vast plain, and nearly surrounded by the waters of the Necker and the Rhine. Its latitude is 49° 26′ N., and its longitude 8° 31′ E.; not very far removed from the meridian from which we set out. The barometer was placed about 51 feet above the mean level of the Rhine.

Ratisbon, the tenth station, is placed upon the Danube, in latitude 48° 56′ N., and longitude 12° 5′.

Munich, the eleventh station, is situated about 62 miles to the south of the preceding. It is seated in a plain on the river Iser, in latitude 48° 10′ N., and longitude 11° 36′ E. The barometer was placed about 48 feet above the ground.

Peissenberg, or Hohenpeissenberg, the twelfth station, is a mountain of Upper Bavaria, distant not more than 3 or 4 miles from the mountains of the Tyrol. The place of observation was its very summit, about 1300 feet above the level of the River Amber, and 1100 above the Leike. Its latitude is 47° 47′ N., and its longitude 10° 59′ E. It is remarked in the Transactions, as a place peculiarly adapted by nature for meteorological observations. Its horizon extends on all sides, but the south, to a distance of above 12 miles; but in the south the Tyrolese Mountains overtop it considerably. It is surrounded by marshy land; and there are no less than three considerable lakes within two miles of it, and several rivers. The northern side of the mountain is covered with wood, and there are large forests in its vicinity. The barometer was placed about 30 feet above the ground.

Buda, the thirteenth station, is the most eastern point of the present comparison. Its longitude being 18° 22′ E., and its latitude 47° 29′ N. It is situated upon the side of a hill upon the banks of the Danube, and surrounded on all sides by hills. The barometer

was placed in the Royal Observatory, about 290 feet above the mean height of the river.

GENEVA, the fourteenth station, is situated upon the extensive lake to which it gives its name, in latitude 46° 12′, and longitude 6° 5′. The Rhone takes its course through the city, and it is surrounded on all sides by lofty mountains. The level of the lake is about 1350 feet above that of the sea.

ST. GOTHARD, the fifteenth station, was the Hospice of the Capuchin Monks, almost upon the summit of the mountain. It is situated 6800 feet above the level of the Mediterranean Sea. It is surrounded on all sides by lofty rocks, some of which rise to the height of 2000 feet above it. The situation is most open to the north and the south, but it is closely hemmed in on every other quarter. There is a small lake close by the dwelling; it is considerably raised above the forests in its neighbourhood.

MARSEILLES is the sixteenth station, and stands upon the shores of the Mediterranean Sea. Its latitude is 43° 18′ N., and its longitude 5° 27′. The ground upon which it stands is uneven, and it is surrounded on the land side by mountains, some of which are not less than 2500 feet high. The observatory is built upon one of the highest points of the town, and the height of the barometer above the sea was 153 feet.

ROME, the seventeenth station, is the most southern point to which the observations extend. It is not very far removed from the Norwegian meridian from which we set out, and agrees almost exactly with that of Copenhagen, thus extending the comparison to upwards of 1200 miles in a straight line from north to south. The exact latitude is 41° 54′ N., and the longitude 12° 55′ E. The city is situated upon the river Tiber, which runs through a part of it, and at no great distance from the Mediterranean on the south, and the Adriatic on the north. The barometer was fixed at a height of about 90 feet above the level of the sea.

PADUA, the last station of this comparison, is a few degrees more to the north, being in latitude 45° 23′ N., and longitude 12° 1′ E. It is seated at the top of the Adriatic, in a fine plain, at the confluence of the rivers Brenta and Bachiglione. The

surrounding country is distinguished by its beauty and fertility. The barometer stood about 60 feet above the level of the sea.

I regret very much the not being able to include London amongst the stations of this interesting survey. The Royal Society, as might be supposed, was one of the first scientific bodies to which the Meteorological Society of the Palatinate addressed themselves for co-operation in the great and truly scientific work which they had undertaken ; and it is very remarkable, and, to an Englishman, very mortifying to remark, that the answer of the Royal Society to the invitation is the only one amongst a vast number which does not appear in the *Transactions*. By some unfortunate coincidence, the years which are included in the Ephemerides are precisely those during which no Meteorological Register was published in the *Philosophical Transactions*; so that the comparison fails at a point which, for many reasons, is one of the utmost interest and importance, but particularly on account of the situation of London being on the extreme west of Europe, and of its being surrounded by the waters of the Atlantic Ocean.

The names of the stations are inserted on one side of the plates, and their longitudes and latitudes on the other ; in conjunction with the former, I have placed the mean heights of the barometer for the year, by which a judgment may at once be formed of their relative elevations above the level of the sea.

I may here remark that I have laid down several more curves, at intermediate places, which are not included in the plates, for fear of rendering them confused. In selecting the present series, I have been guided in my choice by such circumstances as might be supposed to produce the greatest difference between them. Those which I have omitted all concur in the general result.

The principal fact disclosed by the comparison of observations at all these various points must at once strike the eye of the most careless observer—namely, the near coincidence of all the curves. From the shores of the Baltic to those of the Mediterranean ; from the level of the sea to the height of nearly 7000 feet above it ; in every variety of country, from the Alps to the sandy plains of Germany, in every season, in every change of weather, the con-

tinual movements of the barometer correspond in a most wonderful manner. The general law which governs these effects, within these limits, is constant in its operation, although subject to modifications, which it will be highly instructive to trace and appreciate.

In the first place, the oscillations of the mercurial column decrease in proceeding from north to south; and in this way some of the minor movements are obliterated before they reach the extreme southern point. Hence, partly, it is that the three Mediterranean curves are not only flatter than the three Baltic, but less serrated and uneven. If the extreme northern and southern lines were placed in juxta-position, the resemblance would be but faint and imperfect; but they pass so gradually into one another, through the whole series, that their connexion is very manifest. These observations apply most accurately to those places which are nearest situated to the same meridian.

Secondly. There are other modifications which depend upon the relative distances of the places in longitude. By comparing together the most eastern and most western curves which nearly agree in latitude, it may be remarked, that their several points would better correspond, if the former, that is, the eastern, were moved to the left hand about the space of a day or a half. This is more striking upon the larger scale, upon which they were originally laid down, but still may be satisfactorily established by an attentive examination of the plates. It is particularly obvious in the curves of Gottingen and Sagan, and in those of Marseilles and Rome. It is not dependent upon the difference of time, which is consequent upon the difference of longitude, for it is in the opposite direction; and, by taking the latter into consideration, the amount of the deviation is increased.

Thirdly. Besides this regular difference, there are occasional greater discrepancies as we change the longitude, traces of which are generally preserved throughout the meridian upon which they occur. For example, about the 4th of January, at Sagan, a very remarkable elevation of the line occurs, which differs very much from those at the same period at Gottingen and Erfurt, but which corresponds exactly with the curves of Prague and Buda. Again,

about the 18th of March, a much bolder depression of the line takes place at Stockholm than at the same time at Spidberg and Copenhagen; and the same excess of effect may be traced down the more eastern meridians at Sagan, Prague, and Buda, by comparing them with their western neighbours. This difference, dependent upon longitude, will, however, be more distinctly marked, when we come to the explanation of the third plate.

Fourthly. The effect of the difference of the meridians becomes greater as we approach the Western Sea. It will at once be evident that the Brussels curve agrees the least with any of the others. Although it accords in the general outline, almost all the remarkable elevations and depressions are strongly modified. The Marseilles curve, on the contrary, which is only one degree more to the east, agrees very closely with that of Rome. It will be remarked that the whole width of France interposes between this station and the Atlantic, while the former is at a comparatively small distance from the North Sea.

Fifthly. There is another modification which is dependent upon height. The mountain curve of St. Gothard is manifestly flatter, and its inequalities more rounded, than that of Geneva; and it is also worthy of remark how the relative distance of the two decreases as the temperature of the months increases, and augments with their decrease. In the summer the space between them is not half as great as in the winter. This is obviously caused by the expansion of the atmospheric columns in the former season; the difference of course manifesting itself in the increased weight of the upper section.

Sixthly. The abrupt and angular changes of the winter portion of the curves is strongly contrasted with the more gentle and rounded undulations of the summer months, and even the stormy portions of each with those of the more settled weather. These changes extend through the whole series, but it cannot but be remarked that the southern members of the group generally partake more of the latter, and the northern of the former, character.

Seventhly. It may be observed how very generally the corre-

sponding angles of ascent and descent agree. There are certainly many exceptions to the rule, but it is almost universally true, that when the barometer falls very abruptly, it rises to the same amount as suddenly, and *vice versâ.* This evidently points to the equality of action and reaction, and the cause of the exceptions themselves would form an interesting object of research.

Amongst the instructive relations of these comparisons, will be found the theory and practice of the mensuration of heights by the barometer. I shall not now attempt to trace out this connexion in detail, but shall probably recur to it again upon some future occasion.

Before I turn from the consideration of the first two plates, I must remark, that the observations, which were all registered in French inches, &c., have been laid down with the greatest fidelity, except in one or two instances, where the general accordance of the curves manifestly pointed out an error of *a whole inch.* Thus for example, on the 5th of January, in the Spidberg curve, I have shewn, by a dotted line, the course of such a mistake, which would have caused a wide departure from the character of the contemporaneous movements at other stations. I have corrected two other similar misprints; and there are a few other analogous discrepancies in different parts of the synoptic views, which may probably be referrible to errors of the same description, but with which I have not ventured to interfere. Such, I am almost tempted to believe, is the sudden rise in the Stockholm line on the 31st January, and the anomalous fall in that of Spidberg on the 12th February. One of the uses to which, in future, this method of laying down observations may be applied is, to check, within certain limits, the accuracy of different observers. This is the test to which I have occasionally brought the late observations of the Royal Society; and I have in this way discovered, on several occasions, much wider differences between them and the observations of Mr. Howard at Tottenham, than between any two, even of the most remote, stations in Europe, which we have just been comparing.

The next most interesting objects of inquiry are the limits of this correspondence, and the commencement of the reflux which

must necessarily accompany these extensive undulations; for the laws of equilibrium require that a fall of the mercurial column throughout the greater part of Europe, should be accompanied by a corresponding rise in other regions. Unfortunately the observations of the Ephemerides, extended as they were, are not sufficiently comprehensive to fix these important points with all the precision which we could desire. In Plate III., however, I have collected two groups which throw considerable light upon this part of the subject; and I shall now proceed to describe the stations from which they have been selected.

Pyschminsk, the nineteenth station, was the office of the mines in the Ural Mountains of Siberia, situated in the government of Perm. Its latitude is 57° N., and longitude 41° 4′ E. It is the most eastern point to which the registers of the Society extended. Its height was upwards of 2000 feet above the level of the sea.

Petersburg, the twentieth station, is situated on the river Neva, close to the Gulf of Finland. The ground in the neighbourhood is flat and low, and was formerly a vast morass. Its latitude is 59° 56′ N., and its longitude 30° 25′ E.

Moscow, the twenty-first station, is placed about 460 miles to the S.E. of the last. The river Moskwa runs through the city, and in the open country around are some small lakes, which give rise to the Neglina. Its longitude is 37° 31′ E., and its latitude 55° 45′ N.

Mannheim has been here introduced as the type of the western portion of the Continent, in which we have already traced the movements of the atmosphere. From the comparisons afforded by this group we perceive,—

First, that there is neither agreement nor regular opposition in the course of the barometric curves, by extending the observations in the direction of the longitude. This is rendered quite obvious, by comparing together the lines of Pyschminsk, Moscow, and Mannheim, which are at nearly equal distances of 30° apart. I may further add that, in laying down the curve of contemporaneous observations at Cambridge, in the United States, contained, in the Register, in longitude 70° 45′ W., and latitude 42° 25′ N., the same want of correspondence is observable.

Secondly. That the accordance is still maintained upon this

remote meridian, in the direction of the latitude, as appears from the curves of Petersburg and Moscow, which agree together very exactly, notwithstanding they are not situated so nearly north and south as might be wished for the comparison. The quiet state of the atmosphere at Pyschminsk in the summer months of July and August, is another very interesting feature of its curve. This is probably the most inland station at which a register of the barometer has ever been kept, being almost exactly in the centre of that immense extent of land which constitutes the continents of Europe and Asia.

Gothab, the twenty-second station, is situated upon the west coast of Greenland, in lat. 64° 10′ N., and in long. 51° 18′ W. It is the most northern point of the Mannheim Transactions. It stands on the shores of Davis' Strait, at the foot of some very lofty mountains, which rise to the height of nearly 7000 feet. The barometer was placed about 15 feet above the level of high-water.

Edsberg, the twenty-third station, is a small town in Norway, not very far removed from the station at Spidberg, to which the observations, for some reason which is not explained, appear to have been transferred. Its lat. is about 59° N., and its long. 9° E.

Copenhagen and Mannheim are again brought in, to connect the comparison with our previous remarks. I was unable to confine all the observations, as I should have preferred doing, to the same year, because there was no one year that included all the stations that were necessary to my purpose. This series of curves was not laid down like all the others, from two observations in each day, but from the mean of three; which gives them rather a rounder character, but does not materially alter their configuration. In this second group of the third plate, we can discover, I think, with sufficient distinctness, traces of that regular opposition of the curves, which could not but be anticipated from theory. Gothab is situated considerably to the north of all the other stations, and with the interposition of the Atlantic Ocean. It is unfortunately more removed to the westward of the European meridians than could have been wished, but nevertheless the opposition of the movements of the barometer at the end of January,

the whole of March, and parts of April and May, is almost perfect. The accordance of the three European curves of this group is sufficient to shew that they are under the influence of the same law as in the former year, which we have more minutely traced. I have been unable in any way to follow up this interesting part of the subject, for the observations of Gothab have been only published for the six months which I have laid down.

It is in vain, I fear, to point out how very instructing a good series of observations would be from the east coast of Greeland; but we may possibly look forward to a no less instructive set from Spitzbergen, if Captain Sabine should be enabled to carry into execution his proposal of measuring an arc of the meridian in that high latitude. I cannot but anticipate that meteorological *data* of high importance would be amongst the many fruits of such an enterprise intrusted to his hands.

Such being the state of the facts, we are now to inquire whether they are consistent with the general theory which I have proposed. In a system of balancing currents, as I have before observed, any cause which equally affects the velocity of two antagonist streams will change the weight of any perpendicular column, comprehending sections of the two; but, if either of them should be retarded or accelerated in its course without the other, or should they be unequally affected, their compound pressure must alter. We must conclude further, that such unequal change taking place at any particular point of the course of two antagonist currents, must manifest itself throughout their whole line by opposite effects on each side of such point. Let us imagine two such currents: the lower flowing from the poles to the equator, and the upper from the equator to the poles, with such regular velocities that they exactly balance each other, and their perpendicular pressure never alters. Suppose a sudden local check to be given at the centre point of the lower current: the upper will still move forward with its original velocity from its *vis inertiæ;* while on one side of the intervening obstacle its expenditure is fed by a reduced supply, and on the other it meets with the retarded course of the lower current, and must accumu-

late upon it. The barometer therefore which measures the combined pressure of the two currents must rise on one side and fall on the other. This rise and fall will also be sensible to the two extremities of the current, but in a decreasing ratio from the original point of disturbance, on account of the particles of the upper gradually losing their original impulse, and adapting themselves to a new arrangement and a new balance of velocities. Now the order of the phenomena which we have been contemplating appears to me exactly to correspond with these theoretical conclusions. That part of the Continent of Europe over which the observations extend lies about midway in the course of two antagonist currents of the atmosphere, which, from the distribution of the temperature of the globe, must, in an undisturbed state of a gaseous fluid, flow between the pole and the equator. The whole line of its northern extremity, however, is bounded by the ocean, the evaporation from which must constantly disturb that regular progression of temperature upon which the balance of the two streams depends. The mode of this operation I have elsewhere described at length: it will be sufficient here to recall to remembrance, that it is by the heat evolved from the condensation of the rising vapour in the upper regions, and by the cold communicated by its re-evaporation, that such inequalities are produced. The actions and consequent re-actions produced by these irregularities we find constantly communicated from the north, where they originate, in a decreasing degree, to the south. We also find that the counter-action of the barometer, which must necessarily exist somewhere, is not to be traced to the east or to the west; and although observations are wanting at the exact points where theory would teach us to seek it,—namely, to the north of the sea which bounds the northern coasts of Europe,—yet we find evidence of its existence upon the coast of Greenland; which, however, is too remote from the meridian of the chief observations, to present more than a slight correspondence.

The minor circumstances attending the principal phenomena accord no less with the theory. The modification to which the curves are obviously subject upon the shores of the Mediterranean

are referrible to the evaporation of that sea. The northern ocean is exactly situated in the best position with regard to the Continent of Europe for producing powerful effects: by its means the warm waters of the Atlantic are brought in contact with the cold winds and ice of the Arctic Regions. In such a combination of circumstances, evaporation and condensation must reach the most violent extremes, particularly in the autumn and spring of the year. The vast undulations of the aërial ocean dependent upon these circumstances are sometimes broken, but not destroyed, by the gentler influence of the southern waters*.

It is evident that the closest accordance of the curves is to be found amongst those which are situated the nearest to the same meridians; and the curves of the different meridians differ more from one another as they approach the Western Ocean. This is well exhibited by the Brussels line, which varies very considerably from those of Erfurt and Prague; while the curve of Marseilles, which is situated nearly as much to the west, but far removed from the western waters, agrees much more closely with those of Rome and Padua. The influence of the approach of water is also exhibited by the curves of Spidberg and Stockholm, which, in their differences from that of Copenhagen, are doubtless modified by the intervention of the Baltic Sea.

The precession of the western curves before the eastern may also be explained by the situation of the immense reservoir of vapour which is continually rising from the Atlantic Ocean:

* While speaking of the circumstances which are best calculated to produce the greatest disturbance in the aërial currents, and which theory suggests to be the nearest approach of hot water to ice and cold, I may be permitted to observe, that I anticipated that the greatest oscillations of the barometer in this hemisphere would be found about the point where the Florida stream makes its nearest approach to the north. This conjecture I have had an opportunity of verifying by the kindness of Lieutenant Bullock, of his Majesty's ship the Snap, who, while employed by Government in making a survey of the coasts of Newfoundland, kept a very accurate register of the barometer. These observations I have laid down upon the scale; and, although they only extend over the summer months, and consequently those least calculated to exhibit the effect, their curve is decidedly more bold than that of any other situation I have traced at the same season of the year in any other part of the world.

this, when wafted by the currents to the northern shores of Europe, can only progressively exert its influence along the successive meridians. We cannot but lament in this comparison the want of a corresponding station upon the north coast of Africa, from which, amongst many other interesting questions, the influence of the Mediterranean Sea would, probably, have been more clearly determined. In indulging, however, a wish upon this subject, it is difficult to restrain it within these limits, and not to extend it to the revival of a society similar to that of the Palatinate, and the extension of its operations in all directions.

It may possibly be objected to the theory, that these undulations, extending over such a vast tract of the globe, cannot be supposed to depend upon any regular current of the air; because the wind is blowing at the same time in all directions with every modification of force. But it must be remembered that the winds, which are sensible to us, are influenced by local circumstances upon the surface of the earth, and are mostly parts of minor systems of compensation, compared with the grand movement of the atmospheric ocean. It would be as reasonable to expect that the current which flows out of the upper part of a heated room, and is balanced by a counter-current at the lower part, should affect the barometer, as that the direction which the wind assumes in a particular valley, or the retardation which it may experience against any particular mountain, should influence the general movement of the mercurial column. The currents to which the theory refers overtop the Alps, and sweep along uninfluenced by any thing but changes in the elasticity of the medium, of which they form a part;—and thus it is that we find the same curve described upon the summit of St. Gothard and at the level of the sea. I do not mean to deny that these accidents of situation have a local and circumscribed influence; for even the sudden shutting of the door of a heated room, by which we affect the balance of its little system of currents, will cause a delicate barometer to oscillate; but they are lost in the grand outline which we have been considering.

Having traced the general accordance of the barometic curves in the situations which I have pointed out, it would doubtless be a very interesting and instructive task to enter into a further comparison of them, with a view of tracing the causes of their minuter differences ; to inquire how these may be referrible to peculiarities of local situation, and to what extent they are connected with changes of weather. To do this to advantage, however, it would be necessary that the comparison should extend through a number of years. The materials are not wanting in the Mannheim Transactions ; and indeed I have already laid down a far more extended number of observations for the purpose ; but the expense of engraving them is very considerable, and the attention at present given to the study of Meteorology is not sufficient to induce a publisher to undertake their execution with a hope of any advantage. The discovery, however, that some general law governs the oscillations of the barometer, which extends with unerring constancy over large tracts of the earth's surface, seems to me to give a new interest to the pursuits of meteorology. It removes, in a great measure, the charge of uncertainty from its conclusions, and it opens a view of practical utility which is more likely to excite inquiry than the speculations of abstract science. That we may, hereafter, from observations properly arranged, be able to judge at any moment of time, of the force of the winds at distant points, will not, I think, appear chimerical to those who will attentively consider the phenomena which have just been developed ; and it is not difficult to perceive that the interests of navigation may be deeply concerned in a knowledge of the laws of such fluxes and refluxes of the aërial ocean as those which we have been contemplating.

Art. XI.—*On the Measurement of an Arc of the Meridian at Spitzbergen. By* Captain Edward Sabine, of the Royal Artillery, F.R.S.

[With a Chart of Reference.]

To the Editor of the *Journal of the Royal Institution.*

My dear Sir, Portland Place, March 17th, 1826.

In the XXXIXth Number of the *Journal of the Royal Institution*, October, 1825, pages 152—155, you have done me the favour to extract from the work I had then recently published, a suggestion which it contained of the measurement of an Arc of the Meridian at Spitzbergen; and to announce that the proposed measurement had been brought under the notice of the president and council of the Royal Society, previously to the last recess; by whom the propriety of recommending to the government an undertaking so important to the advancement of natural knowledge, was then, namely in October, 1825, under consideration. I am induced, by the favourable mention you were then pleased to make of the projected enterprise, to solicit a place in the ensuing number of the Journal, for the communications which I have since made on the subject for the purpose of being laid before the council, and which, although they have not for the present succeeded in obtaining the desired recommendation, may still, I persuade myself, be instrumental by their publication, to its ultimate adoption and success.

I must premise, that the subject was first brought under the notice of the president and council of the Royal Society, previously to the last recess, (in May or June, 1825,) by Mr. Herschel, to whom I had sent the proof-sheet of my work, (then in the press,) from which your extract was subsequently made; and I had then the pleasure of hearing from several members of the council, that the project had been very favourably received, and that they were desirous of all the additional local information I could procure for them. The president, Sir Humphrey Davy, further did me the honour of asking if I would be willing to conduct the un-

dertaking, should it be determined to recommend it to the government; which of course I expressed my readiness to do.

On the commencement of the present session of the society, I addressed the following letter to Mr. Davies Gilbert, for the information of the Council, containing such additional particulars of local information as I possessed, either in my own knowledge, or from competent and satisfactory authorities; Mr. Gilbert having acquainted me with his intention to bring the subject, which met with his warm support, under formal consideration.

Captain Sabine *to* Davies Gilbert, *M.P.*, *Vice President of the Royal Society.*

My dear Sir, Portland Place, February 8th, 1826.

I beg to trouble you with a few remarks on the project of measuring an Arc of the Meridian at Spitzbergen, previous to its discussion at the council of the Royal Society.

It is not necessary that I should at this time enter on the reasons which have induced, for more than a century past, measurements to be made of portions of the meridian, for the purpose of determining the figure of the earth. The question *now* is rather, shall all that has been effected hitherto in this method, with so much labour and expense, remain in its present incomplete and inconclusive state? or, shall the method be pursued, until the result which it is capable of giving be attained?

There have been two arcs measured in the vicinity of the equator; the Indian one, in particular, deserving of the highest considertion, from its extent, and from the care bestowed on its details. To give to these arcs their full value in the proposed determination, there is wanting a corresponding measurement or measurements at the polar extremity of the meridian, with which they may be combined.

Several stations have been named for this purpose besides Spitzbergen, *viz.*, The North Cape; Greenland; and Iceland. From personal knowledge of all these countries, (except Iceland, to which however, the remark equally applies,) I can venture to

give a practical opinion, that there can be no question as to the superior eligibility of Spitzbergen; a water communication along the whole line of operations, constitutes the superiority; and to those who have thought much on the details of such proceedings, it will not be necessary to explain that this is a point of the very first importance: a view of the chart of Spitzbergen will best shew its remarkable fitness in this respect.

An arc falling a little short of $4\frac{1}{2}°$ is comprised between Hope Island and the Seven Islands; being the northern and southern extremities of the group which passes under the general name of Spitzbergen; and which may be seen by the chart to be so connected by intermediate land, as to admit of their being united trigonometrically.

The value of an arc of $4\frac{1}{2}°$ in the latitude of Spitzbergen, towards deducing the proportion of the polar and equatorial diameters by its combination with an arc near the equator, is equivalent to one of 9° in the mean latitude of France, and of 7° in the mean latitude of Britain; its value, therefore, in the ultimate determination, may be estimated by the known importance which is attached to the national arcs of Great Britain and France. It may be further noticed, that it is equivalent to an arc in Lapland, of nearly six times the extent of the arc measured by the French Academicians; the importance of which at this day is such, in the view of the first geometrician of the age, that M. Laplace has recently proposed that a fresh commission should be sent to re-determine the latitudes of the extremities.

The expediency, then, of undertaking such a measurement at Spitzbergen, is principally to be considered in reference to the natural difficulties which may impede its execution. And on this point, having myself actually resided some weeks on shore at Spitzbergen,—having conducted there operations of a similar nature,—having personal knowledge of the general character of the country to be traversed, the difficulties it presents to persons carrying astronomical instruments, and the modes and facilities of overcoming those difficulties,—and having made observations of much delicacy, continued through many successive hours, and

for successive days, at the summit of one of the hills of principal elevation, such as would probably form the greater part of the trigonometrical stations,—I may venture to hazard the opinion which that varied experience warrants. The subject was in my mind when on the spot, and I have since reflected continually in reference to it, and have heard, I believe, most of the objections which from time to time have been suggested in conversation, against its practical accomplishment. I still, however, entertain the opinion formed on the spot, *viz.*, that there is no reason to anticipate any difficulties, either of climate or country, but such as may be surmounted by the patience and exertion requisite in such operations, or which, being surmounted, would in the slightest degree interfere with the accuracy of the result. I may observe, that I am speaking of difficulties, which I think it not improbable I may be myself called on to meet; and that I am not likely, under such circumstances, either lightly or inconsiderately to underrate them.

It is very satisfactory to me to be enabled to add, that the inferences I had drawn from my own personal experience at Spitzbergen, have been very greatly strengthened by the highly interesting and important information, as regards this question, which Mr. Crowe, his Majesty's vice-consul at Hammerfest, the establisher and proprietor of a British settlement at Spitzbergen, has obtained in the last summer. The following extracts are from a communication which Mr. Crowe has made to Lord Melville.

"It having been mentioned to me by Captain Sabine in a conversation I had with him previously to my leaving England last summer, that the Admiralty might have it in contemplation to send a vessel in the direction of Spitzbergen for certain scientific objects, and that any information would be acceptable which might tend to facilitate the progress of such a vessel, I directed the master of a small cutter of 40 tons, who was to sail from Hammerfest to the settlement at Ice Sound, to penetrate up Wyde Jantz Water, an arm of the sea which intersects Spitzbergen in a north and south direction, respecting the free navi-

gation of which Captain Sabine had expressed a wish to be informed. The vessel accordingly did ascend to the parallel of Ice Sound (78°), and the master reports it to have been perfectly free from ice. He next went round the west coast as far as Waldon's Island, adjoining the Seven Islands, without meeting with any impediment; and although many shoals of ice were visible from thence, there were many open channels through which he might have navigated still further in that direction. A vessel belonging to myself, the year before last, ascended half a degree farther north than Table Island, but more to the westward.

"M. Sharostin, an intelligent Russian, with whom I have frequently conversed, actually passed thirty-nine winters on Spitzbergen, and resided there for fifteen years without having once left the island. He declares that during his residence he invariably found the coasts free from ice for four and sometimes for five months in every year. I am enabled to add, that my own vessels have frequently navigated the coast from Ryke Yse's Islands the south-east extremity, round the West Coast, to the Seven Islands at the north-east extremity, and that four times out of six they might have circumnavigated Spitzbergen."

Mr. Crowe has further acquainted me that his brother, who sailed in the cutter up Wyde Jantz Water, represents the land on either side as being conveniently traversible, the hills of moderate elevation, and the valleys running well into each other.

Mr. Crowe has requested me to express his readiness to attend at any time at the council of the Royal Society, should his presence appear desirable, and I need not add that my attendance is always at their command.

These are, I apprehend, the best sources from whence information can at present be attained; but, without doubt, the most satisfactory mode of ascertaining whether the natural difficulties to be encountered ought to weigh against the value of the result that would be obtained is, to send a vessel in the present summer for the express investigation. For this purpose there would be required—no wintering in the high latitudes—no particular cost in strengthening or fitting the ship for the service—no second ship

as a consort in case of accident, because there are permanent settlements at Spitzbergen at which merchant-vessels are always to be found—no risk of life, beyond what the Norwegian sailors annually encounter in quest of eider down. One of the ordinary surveying ships, relieved for six months from her accustomed employ, would then place it in the power of the council to decide, on full and competent knowledge, on the propriety of recommending the measure to be carried into execution.

I conceive that a single season, the present summer for example, would be ample for the most thorough investigation, in which every station should be personally visited—the angles and latitudes observed with inferior, that is to say, more portable, instruments,—and the situation of a base selected, with reference both to the survey generally, and to the nature of the ground. The report should also contain so thoroughly-digested a scheme of further proceedings, as should enable the council to judge of the merits of every part of the proposed plan, previously to its being undertaken. Such a report would probably prove more than half the labour of the whole operation.

Should the council think that I could be advantageously employed in conducting such an investigation, my services, as you well know, are at their command. Accompanied by a second officer of the ordnance and a steady serjeant of Artillery, I should feel little doubt either of putting the question, as regards Spitzbergen, at rest for ever, by proving the impracticability of the operation, or of furnishing such a report as I have described, whereby its completion, if it were expedient to be pursued, could be looked forward to with certainty. I remain, my dear Sir,

Yours, very faithfully,

EDWARD SABINE.

In addition to the above letter, I furnished Mr. Gilbert with a second, for the further satisfaction of the council, which I had received from the Rev. George Fisher, Fellow of the Royal Society, who had visited Spitzbergen in 1818, at the instance and recommendation of the Royal Society, to conduct there a series of ex-

periments with the pendulum, for the same purpose of determining the figure of the earth.

(Copy.)—*The* Rev. George Fisher *to* Captain Sabine.

My dear Sir, 20th Feb., 1826.

In reference to the subject of your proposed operations in Spitzbergen, I have only to observe that I have seen the whole of the western side of that island from the South Cape to the Seven Islands, and been on shore at many places for several weeks together, and I cannot see any *peculiar* difficulty whatever either in the triangulation, or the astronomical part of the operation. With respect to the former, I think that the fiords which remain frozen till the early part of the summer, would be no small advantage in a way which I need not suggest to you; and with respect to the latter, there are no difficulties whatever, but what similar observations in other climates are subject to; for as your observations would be confined to stars near the zenith, refraction has little or nothing to do with it. And upon the whole, I think it not only very important and interesting, but *exceedingly practicable.*—From, dear Sir,

Yours most truly,

(Signed) George Fisher.

Stanstead Vicarage, Essex.

These letters were submitted, and the subject discussed at a meeting of the council on the 9th of March, and their decision was communicated to me by letter from the Secretary on the following day, returning thanks for the communications and proposal, and acquainting me, that "under existing circumstances, the President and Council do not deem it advisable to offer any suggestion to Government upon the subject."

Such has been the progress of the proposal to measure an Arc of the Meridian at Spitzbergen, so far as it can be in the power of individuals to urge its consideration; their power extends only to bringing it under the notice of the Royal Society, which, with great propriety, is considered as standing between the govern-

ment on the one hand, which alone can give efficiency to such enterprises, and science on the other, promoted as it might be by the services of individuals ready and willing to be employed in its advancement. The subject having thus been brought under the notice of the Council of the Society, it will remain with them to resume its consideration, should they think fit to do so, whenever a suggestion to government may be judged by them more advisable than at present. In the mean time, it may be permitted to hope, that the circumstances, whatsoever they may be, which in the view of the Council impede its present execution, may not always continue to exist; and that the recommendation to Government, preceded by the essential preliminary step of a sufficient examination of the locality, may be looked for from the Royal Society at no very distant period, and before we lose the advantages which we at present possess in our familiarity with the navigation of the higher latitudes, and our experience in surmounting their natural difficulties.

I am, my dear Sir,

Very truly yours,

EDWARD SABINE.

ART. XII. *Proceedings of the Royal Institution.*

THE Public Lectures, delivered in the Amphitheatre of the Royal Institution, were commenced on Saturday, the 4th of February last, when Mr. Brande delivered an introductory discourse to his lectures on the Atomic Theory.

He observed, that it was one of the principal duties of the professors of this Institution, to divest, as far as possible, the higher and more abstruse parts of the sciences of which they treat, of the technical difficulties and verbal redundancies in which they are too commonly shrouded, and by placing the *facts* upon which they are founded in their simplest and least obstructed point of view, to shew how far they are applicable to the purposes of common life; that is, how far they have tended to improve arts

and manufactures, to increase our comforts, or to add to our luxuries.

Under this impression, he should attempt a simple and concise statement of a branch of chemical theory, which has lately attracted much and deserved attention; and which, while it tends to disperse the difficulties that beset some of the higher and more abstract departments of experimental investigation, has, at the same time, materially contributed to facilitate and improve the practical detail of the science, and to confer no inconsiderable benefits upon a very large proportion of those numerous branches of human industry, which have their origin in the precincts of chemical philosophy.

The inquiry to which he alluded was that which investigates the statical laws of chemical combination; and as the whole object of chemical science is to examine into the mutual actions and re-actions of the elementary substances upon each other, by which the composition of matter is governed, all researches into the *general laws* connected with such combinations must, of necessity, prove important, as affecting the fundamental doctrines of our science.

In this subject no successful advance could have been made until some progress had been attained in chemical analysis—until methods had been devised of determining, not merely the component parts of bodies, but the proportions in which they enter into union—until the general laws of chemical combination had been to a certain extent determined. Bergman and Wenzel, but especially the former, are entitled to the merit of having led the way in this truly useful and essential branch of knowledge; and in looking through the pages of chemical writers, shortly after that period, we find, more especially in the laborious analyses of Klaproth, facts upon which the theory we are about to develop may be said to rest; that is, we discover a certain uniformity in the combining proportions of bodies, pointing at the definite laws by which they are governed. Happy illustrations of these laws, divested of all hypothetical aspect, and immediately brought to bear upon the minute and accurate details of practical chemistry,

are to be found in some of Dr. Wollaston's papers in the "Philosophical Transactions;" but before we proceed to discuss their contents, it will be right to say something of the earlier history of our subject. This we must preface by stating, that it has been ascertained that the simple or elementary bodies, as well as their primary compounds, unite with each other in certain quantities or proportions only, and that to these they are ever obedient under whatever circumstances their union may have taken place. (This position was illustrated by reference to a variety of natural and artificial compounds.)

That bodies, then, are obedient to *certain* definite laws of combination is the first doctrine that is to be established. This leads to a second and highly curious and important fact, which is, that where two substances, by combining in different proportions, form two or more compounds, the second or third proportions in which they combine are multiples of some simple number representing the *first*. (This was shewn by reference to several experiments.)

These facts have been explained upon the idea that certain indivisible atoms of matter, some simple and some compound, unite to each other, and that their relative weights are represented by those in which they combine—an assumption altogether gratuitous and hypothetical, but which has led to the adoption of the term *Atomic* theory; we shall, however, rather prefer the term, *theory of definite proportionals*, or of *chemical equivalents*, in our discussions of these matters.

The most important step in this inquiry appears to be that made by Richter, of Berlin, to whom we owe the discovery of the general reciprocity of the saturating proportions of bodies, a law, the experimental verifications of which are set forth in his "Geometry of the Chemical Elements," published in detached parts between the years 1791 and 1802. (Some of Richter's tables were then shewn and explained.)

It follows, as Richter remarked, from an examination of these tables, that when two neutral salts mutually decompose each other, the resulting compounds will also be exactly neutral. Let

us suppose, for instance, nitrate of lime composed of 54 nitric acid, 28 lime, to be decomposed by carbonate of potassa, consisting of 22 carbonic acid, 48 potassa. It is clear that the quantity of carbonic acid in combination with the potassa is exactly that required to saturate the lime in union with the nitric acid; and that the potassa and nitric acid are also in such reciprocal proportions.

The use of the numbers attached to the acids and alkalies, on these tables, is infinitely more important and extensive than can at present be made to appear; this will, however, be evident, when the principles on which they are found have been explained.

We have now then established the first position, chiefly upon the authority of Richter, that bodies are obedient to *certain definite laws of combination*—that the quantities of alkaline bases requisite to neutralize equal weights of any one acid, are proportional to the quantities of the same bases requisite to neutralize the same weights of every other acid: upon these data, to be more explicitly expounded hereafter, are founded an infinite number of important theoretical deductions and practical conclusions. We shall now, therefore, turn to our second topic of inquiry, which is to examine the laws of combination, where bodies unite in more than one proportion, and where we shall find that the second or third proportions are multiples of the lowest number representing the first. To quote a simple but very beautiful illustration of this fact, for which we are indebted to Dr. Wollaston, I need only refer to the numbers upon one of the tables already shewn, in which carbonate of potassa is shewn to contain just half the quantity of carbonic acid, which is united to the potassa in the bi-carbonate. (A table shewing the results of Dr. Wollaston's analysis of the oxalate, binoxalate, and quadroxalate of potassa, was referred to here.)

The original discovery or detection of this law of multiple proportions, is, I think, due to the late Mr. Higgins, of Dublin, and is to be found in his "Comparative View of the Phlogistic and Antiphlogistic Theories," originally published in 1789. Here, after defining what he means by the term primary or ultimate particle,

he assumes that bodies combine either particle with particle, or one with two, three, four, and so on; and he cites, certainly, a very apt illustration in the case of certain compounds of nitrogen, a body which is now known to unite in five proportions with oxygen, and in which every additional proportion is a multiple of the first.

			N.	Ox.	
Thus	1 + 1	or	14 +	8	nitrous oxide.
	1 + 2	or	14 +	16	nitric oxide.
	1 + 3	or	14 +	24	subnitrous acid.
	1 + 4	or	14 +	32	nitrous acid.
	1 + 5	or	14 +	40	nitric acid.

It is upon this view of combination that Mr. Dalton founded his *atomic theory*, that he considered the ultimate ponderable atoms of bodies as uniting to each other according to definite laws of multiple proportion; and he assumed hydrogen as the unit or radix of his scale.

The first work on chemistry in which the combining proportions of bodies were represented by numbers, shewing the relative weights in which they unite, and in which the theory of definite proportionals is brought forward as a *convenient statement of facts independent of all hypothetical or atomic considerations*, is Sir H. Davy's *Elements of Chemical Philosophy*, published in 1812; and though the numbers which he has adopted refer to a peculiar view respecting the composition of water, and consequently differ from those which have since been adopted, his plan and principle has been followed by all succeeding systematic and elementary writers, and have been productive of infinite convenience and simplification.

The principle of numeric representation having been already noticed, it remains to enter into some of its practical details, and especially to consider what substance may most conveniently be adopted as a radix or as = 1. Upon this question the opinions of chemists are pretty well concentred in two points; one in favour of hydrogen, and the other of oxygen; the former adopted as being the lightest body in nature, as combining in the smallest

proportion, and consequently, as tending to a series of numbers which, for all other bodies, are multiples of itself; whereas oxygen is preferred on account of its universal agency, and very frequent occurrence in compounds. Since I have taught chemistry in this school, I have always adopted the former series of numbers; and the truly important facts more lately adduced in favour of the hydrogen unit by Dr. Prout, have greatly tended to confirm me in my choice: at the same time, when I say that Dr. Wollaston and M. Berzelius are the advocates of the oxygen radix, I need not add that I bow to their opinion with the utmost deference, but yet cannot be convinced of its advantage. To the experienced chemist, the matter is of very little importance; but to the pupil, the perspicuous simplicity of the former mode of proceeding seems to me to give it decided preference.

(Experiments were now shown in reference to the composition and decomposition of water and of muriatic acid, and thence were deduced the equivalents of those compounds, and of their elements, oxygen, chlorine, and hydrogen.)

Now since bodies are thus shown to unite in certain proportions only, and since these bear certain definite ratios to each other, it is evident that where the constituents of bodies are gaseous or aëriform, we have an opportunity of examining the volumes or bulks of the combining bodies, as well as their weight, and these, as we have been taught by the interesting inquiries of Gay-Lussac, bear the simplest relations to each other, gases combining either in equal volumes, or one and two, or some such simple proportion: and when gases, in consequence of combination, alter their original volumes, the change of volume is always correspondingly simple.

After some further general and historical remarks upon the subject of the Atomic Theory, and an enumeration of the principal writers upon the subject, Mr. Brande stated the plan of arrangement to be adopted in his future lectures, and enumerated the various applications of the doctrine of equivalents which they were intended chiefly to illustrate.

On Tuesday Evening, the 7th of February, Mr. Wallis commenced a Course of Lectures on Astronomy, which have been illustrated by an exceedingly instructive and well-managed series of transparent drawings, and of machinery exhibiting the motions and affections of the planetary bodies. In his introductory discourse, the principal objects of the science, and the mode of treating and explaining them which he proposed to adopt, were stated. The following is a portion of the outline which was then given, and of which the principal positions were illustrated by reference to some extremely ingenious models and experiments.

"Astronomy is that branch of science which treats of the phenomena and motions of the heavenly bodies, including also several phenomena of the earth. It may be divided into two departments—that which respects, simply, facts ascertained by observation, and that which may be termed Physical Astronomy, by which their motions, their distances, and the figures of their orbits may be determined.

"Astronomical truth does not admit of that species of evidence which belongs to experimental science; most of its conclusions rest on analogical argument; but it is the purest and most simple application of that mode of proof, and, when profoundly investigated, produces conviction scarcely less satisfactory than practical demonstration. Physical Astronomy is an hypothesis which consists in the extension of the principles and laws of Dynamics, as they affect matter on or near the earth, to the motion and regulation of the masses of the celestial bodies. Of this we have an instance in the figure of the moon's orbit in its reference to the earth. It is found by actual experiment that bodies fall to the earth with an accelerated velocity, passing, during the first second of their fall, through the space of about 16 feet, and increasing as the squares of the time during which they fall. Now as from observation we know the period in which the moon revolves about the earth, and from her parallax her distance from the earth taken in diameters of our planet, mathematicians can thence determine the figure of her orbit, and, consequently, the amount of the deflection from a tangent to that curve in any given portion of that time. Taking

then the moon's period at 27.3 days, and her distance in semi-diameters of the earth, at nearly 60, in one minute of time the deflection from such tangent is rather more than 16 feet. From this, if we suppose that the terrestrial gravity is the centripetal force which occasions the deflection, it must be at that distance lessened in its intensity, in a ratio that is as the square of the distance : for such a force as that which causes bodies at the surface of the earth to descend towards it 16 feet in *one second*, if diminished in this ratio, would occasion them to pass over only this space in *one minute.* Whence we are able to shew that a similar force with that of gravity is the centripetal force concerned in the production of the moon's orbit, and, if similar, why not identical ?—for our only knowledge of gravity, as a force, is the measure of its intensity estimated by the velocity it imparts to matter : and as it respects the ratio of decrement in the force, if gravity be conceived as particles of any kind diverging from a centre, their dissipation, if reckoned on the surfaces of concentric spheres, would be inversely as the squares of their respective diameters. This application of mechanical principles, in their free and uncontrolled condition, is that on which we shall proceed in this course of Lectures. We must therefore make certain deductions from all our experimental proofs, for they can only illustrate, not demonstrate, the facts or phenomena to which they refer. Physical Astronomy being then an hypothesis, it requires, in order that its conclusions may be fully apprehended, that we exercise our powers of imagination to abstract from the experiments of the lecturer those circumstances of a mechanical nature by which they are unavoidably encumbered. Within the limits assigned to this course of lectures, it will not be possible to submit more than an outline of this noble science to your notice, but we shall endeavour to discuss the most leading and important topics. To advert to another instance of the application of mechanical principles, all instances of celestial motion are instances of curvilinear motion. Now in the composition of motion a curve will be described by a body only when it is acted on by an equable and an accelerative force—for the composition of two equable

forces can produce only rectilinear motion. Now gravity supplies an accelerative force, and hence we extend the principle of gravity to all the bodies in the universe, assuming the projectile force as impressed originally on all the bodies which are found revolving round others. The production of both these species of motion will be practically shewn by mechanism in the course of these instructions."

Monday, February 13*th.*—Dr. Gordon Smith commenced a private course of Lectures, in the theatre, on *State Medicine*, more generally denominated, in this country, *Medical Jurisprudence* *. The objects and importance of this study formed the subject of the introductory discourse, of which the following is an abstract:—

It commenced with an allusion to certain circumstances that induced the lecturer to devote his attention to the cultivation of this science, with the view of applying it to the exigencies of his own country—which, for several years, he has been sedulously engaged in—and by anticipations of future success, through the advantageous opportunity now afforded of making known its claims to those who are able to advance them.

In alluding to the neglect with which the *study* of this science has been so long treated in the British empire, although its *practical* importance has been daily proved, by the frequent occasions on which medical aid has been required on the part of public justice, the notorious discrepancies among professional witnesses were described as having been, and, indeed, as still being inevitable, for the simple reason—that no care is taken, on their part, to accomplish themselves for the peculiar duty they are, in such circumstances, called upon to perform. The reproach, however, which may justly be cast upon medical testimony should not be extended to medicine itself.

The study of State Medicine, though more directly within the

* Since the lectures commenced, the hour has been complained of as generally inconvenient; it is, therefore, intended to select an earlier one for future courses.

province of two particular professions, has claims on the attention of the intelligent generally. As, in England, every respectable man is liable to sit in judgment on the fortune, life, or reputation of his neighbour, it ought to be his concern to qualify himself, in some degree at least, for the able and conscientious discharge of so important a duty. It interests directly the tribunals, whether civil, criminal, or ecclesiastic; and as the highest court in the kingdom is composed of the highest orders in the state, rank does not exempt from participation in the general concern.

In giving a short account of the rise and progress of the science, allusion was made, in the first instance, to the extent of the literature belonging to it. Among some *general* treatises which the lecturer exhibited, was one work consisting merely of a list of titles of books in this department down to 1818,—a list by no means complete even to that period, since which not a few have been added. The work in question contains the titles of 4993 productions in the two departments of *Forensic Medicine* and *Medical Police*, and many of these consisting of several volumes, not less than 10,000 are in all probability known to be in existence,—of which there are not more than six, in the English language at least, that have any claim to notice as general treatises, while the amount of particular dissertations is probably not so great.

The origin of that connexion between the administration of justice and the application of medical science to public purposes, which has been systematically cultivated to this great extent, cannot be dated higher than the middle of the seventeeth century; and its basis will be found in the *Constitutio Criminalis* of the Emperor Charles V. It is in that code made imperative on the criminal tribunals of the empire to call in the aid of medical men, for the purpose of determining certain cases that are specifically pointed out, and in which the lights of medical science are considered necessary; these cases had their share of notice in the commentaries to which the *Constitutio Carolina* gave rise, and thus began the formation of the *Bibliotheca Medicinæ Publicæ*, which, it is to be hoped, is yet far from being completed.

The principal labourers in this field have certainly been the Germans, and the Italians have given copious proofs of their industry. Since the revolution, the French have amply made up for lost time, and have produced many works of great excellence and utility; the science is at present a favourite one in that country, and is an object of considerable value in the eye of the government.

During the last two centuries, chairs have existed in the continental universities, from which the science has been publicly taught, and professorships are established in the medical schools of France, in which the candidate for qualification to practice must pay attention to this branch, along with his other studies. Nay, it is at present in contemplation to erect a separate school, for educating medical men for the special service of the state—a measure which, though it may appear an unnecessary refinement to some, is calculated for great utility.

In our own country there has been comparatively but little done of a corresponding nature. About twenty years ago, his late Majesty founded a chair of this department in the University of Edinburgh; but as it has been optional on the part of the student to give or withhold his attendance, we are afraid that the endowment, notwithstanding the ability of those who have held it, has not done much for the advancement of its notoriety. It is a study which ought to be enjoined upon every medical man; and, when it is considered, that in his capacity of a witness before a public tribunal, the interests of the profession are absolutely committed to his management, it is almost incredible that the directors of professional education should not have shewn some solicitude to qualify those, by whom they are represented to the world, for the adequate discharge of so important a task.

The public application of medicine resolves itself into two branches: the one embracing its connexion with the business of courts of justice, and the other the enactment of laws, and the enforcement of regulations for the preservation of the general health of ne community; the first being designated Forensic Medicine, and the latter Medical Police: these two conjointly

forming the science collectively, termed State or Political Medicine, or what has been usually called Medical Jurisprudence, a term of more than questionable accuracy.

In the printed prospectus of the course, the author has observed this division, placing that of Forensic Medicine first; and the residue of the lecture consisted of a commentary on the outline, or rather catalogue of the topics belonging to each, as sketched in the prospectus. We subjoin the outline in question, to which will be added, a brief notice of such points of the commentary as may be essential to a more explicit comprehension of terms and allusions that can hardly be familiar to readers in general.

"DIVISION I.—THE DUTIES OF THE FORUM.—JUDICIARY, OR
" FORENSIC MEDICINE.

" SECTION I.—*Sudden Death, under mysterious and unusual*
" *circumstances.*

" THE REALITY OF THE EVENT.—States resembling, or liable to be
" mistaken for death—The consequences of such mistake—Means of
" discriminating, and precautions to be observed.

" PERSONS FOUND DEAD.—Distinction of cases of an accidental, or na-
" tural description, from those of a violent or criminal complexion, in
" the absence of historical evidence—Forms of inquiry—Coroner's
" Inquest—Medical duties—Appropriate method of examining dead
" bodies for judiciary satisfaction.

" DEATH BY VIOLENCE.

" I. HOMICIDE.—The determination of certain questions without the
" light of historical information; *e. g.* the import of signs of interference,
" or marks of violence about the body, in regard to the following points:
" as to the real cause of the person's death; as to their infliction during
" life, or occurrence after death—the possibility, or improbability of their
" having been self-inflicted, in the following particular cases:—

" A. *Poisoning.*—Under which will be included the science of TOXI-
" COLOGY at large; comprehending the history, action, treatment, and
" detection of every individual poison.

" B. *Suffocation.*—Which includes the phenomena and proofs of death
" by noxious respiration, drowning, hanging, strangling, smothering,
" choking, &c.

" C. *Wounds, bruises, and mechanical violence.*

" II. Suicide.—Special application of preceding doctrines to cases of
" self-destruction.

" III. Prolicide, or the destruction of offspring—comprehending

" A. *Fœticide.*—The destruction of the *immature fœtus*, commonly
" termed *procuring abortion.*

" B. *Infanticide*, or, the destruction of the infant at the natural time of
" birth; under which will be included some discussion on the state of
" Jurisprudence in this matter, and an elaborate inquiry into the *peculiar*
" nature of the evidence required in cases of *child-murder.*

" IV. Survivorship.—The discrimination of the longest liver, where
" two or more persons have perished from a common and simultaneous
" cause,—a question sometimes of the greatest consequence in the suc-
" cession of inheritance.

" Section II.—*Violence, not involving the issue of Death.*

" I. Maiming or Mutilating.

" II. Surgical Operations.—To be considered as to their propriety
" and warrantability under various circumstances, and comprehending the
" legal responsibility of surgeons as to the issue.

" III. Corporal Punishment.—More especially as connected with
" the usage of military service.

" IV. Injuries to the Female Sex.

" Section III.—*Disqualifications for social Functions and official*
" *Situations.*

" I. For General Purposes.

" A. *Moral and Intellectual* defects and peculiarities, including *Insanity*, and all varieties of mental derangement.

" B. *Deaf and Dumb.*—Verification of the fact.

" II. For Marriage.—The consideration of physical peculiarities and
" defects, including certain pleas of *divorce*.

" III. For Military Service.—Disqualifications for assuming or
" retaining the military profession.

" IV. For Holy Orders.

" V. Impostures, connected with the foregoing and other cases—
" the detection of feigned diseases, and the disproval of unjust impu-
" tations.

SECTION IV.—*Miscellaneous Questions.*

" I. HUMAN GESTATION.—Its verification, term, and fallacies, involving the doctrines of legitimate birth, and the question of female reputation.

" II. MONSTERS.—Particularly the case of sexual ambiguity.

" III. AGE AND IDENTITY.—The distinction and discrimination of these questions by physical considerations alone.

" IV. LIFE INSURANCE.—Comprehending the basis of exceptions, and the means of estimating insurability.

" V. HEREDITARY DISEASES AND PECULIARITIES.—Including the influence of the maternal imagination, in the formation and developement of the uterine child.

" VI. THE ECONOMY OF MEDICAL EVIDENCE.

" Throughout this division Dr. Smith's work, entitled " The Principles of Forensic Medicine," &c., will serve the purpose of a text book.

" DIVISION II.—THE DUTIES OF THE SENATE, OR, MEDICAL " POLICE.

" It is impossible for the Lecturer to pledge himself, at present, either as to the exact extent, or precise details of this Division. The following enumeration of the chief topics will, however, convey some idea of its importance :—

" I. AGES.—Characteristics and import of the several gradations in the period of human life, from the hour of birth to its natural decay, and final extinction—comprehending many circumstances relative to physical education and economy—as gymnastic exercises, moral management, &c. &c.

" II. MARRIAGE AND POPULATION.—Proper period for marriage—fecundity—and mortality—as questions of State importance.

" III. MANNERS.—Their influence on health.

" IV. AIR, FOOD AND DRINK.—Importance of their purity, and wholesomeness—including the medical consideration of *nuisances, adulterations, culinary poisons, public cleanliness, regulations for markets, slaughter-houses, burial-grounds*, &c. &c.

" V. TOPOGRAPHY.—Comprehending *climate, soil, meteorology, productions*, &c., of countries and particular situations.

" VI. CLOTHING AND DWELLING PLACES.

" VII. Public Buildings for numerous inmates.—*Manufactories,* " *barracks, ships, prisons, alms-houses, work-houses, churches, hospi-* " *tals, asylums,* &c.—as regards ventilation, warmth, economy, discipline, " and labour.

" VIII. The Poor.—Employment and management of, with a view to " preserve them from disease.

" IX. Contagious, Epidemic, and Endemic Diseases.—Enume- " ration and history of the prevalent varieties—precautionary measures " against them—*quarantine—small-pox—hydrophobia,* &c.

" X. Dangers in certain Situations—As in *mines*—from *light-* " *ning,* &c.—measures precautionary and remedial with regard to acci- " dents—*humane, or resuscitating institutions.*

" XI. Medical Economy and Ethics.—Medical education—dis- " tinctions—surveillance and corporate authorities—great importance of " *anatomy,* and necessity of interference on the part of Government— " plan for removing existing impediments—dangerous indifference as to " the qualifications of *accoucheurs*—necessity of studying *State Medicine* " —duties, privileges, and moral deportment of medical men—their quali- " fications for *military service*—propriety of appointing them to the office " of *Coroner*—professional remuneration—great and general disadvan- " tages of the present system—proposed improvements."

Death, occurring suddenly in the healthy, or apparently healthy, state gives rise to a variety of occasions on which inquiry must be instituted into the cause, and for the discovery of which the aid of medical investigation is indispensable. It may often, however, be a matter of importance to decide whether that event has really taken place, or whether it be merely simulated; for in consequence of mistakes and doubts on this point, very untoward results have happened on the one hand, and great inconvenience has arisen on the other. The premature abandonment of the dying, and the over-hasty disposal of the dead, are matters worthy of general attention; and, although there may have been alarm and exaggeration with respect to the latter, beyond what real history will warrant, yet the necessity for caution is by no means without foundation.

The circumstance of finding a dead body, in an unusual situation, is directly connected with judiciary interference; and, in the

absence of historical information, the authorities must look to the assistance which medical science alone can afford. A knowledge of the healthy structure of the body, and also of the deviations from this, which may be met with under every variety of circumstances, will often lead to the detection of the cause of death. It will enable the parties to reconcile the event with the circumstances in which it may have happened, and either to dispel unfounded suspicions, or facilitate the detection of crime. Thus, it may be that certain marks about the body are construed, by the uninformed bystander, into evidences of violence, while the knowledge alluded to may identify them with some natural cause, or shew that they could not have had any share in producing the catastrophe. The case of Sir Edmondbury Godfrey was here alluded to as an illustration, for although he was found dead, with a sword in his body, the surgeons who examined him, decided that it must have been thrust in after death. Persons may be taken dead out of the water, and yet not have been drowned. It is possible also, that poison shall be found in a body, and yet there may be satisfactory evidence that it was not administered during life.

The course of procedure, according to the law and custom in such cases, being briefly alluded to, introduced some animadversions on the glaring inefficiences of the coroner's inquest. In the great majority of instances it is a mere form; and although it may not be desirable that it should be otherwise, yet, looking to the connexion that subsists between such inquiries and scientific research, there is abundant cause for censure, and great room for improvement.

The examination of the dead body (even for private satisfaction, as to the cause of death, or the nature of an obscure pre-existing disease) is comparatively seldom performed as it should be—for judiciary satisfaction probably never—in England, at least, the right methods being generally unknown, and certainly unpractised. Forensic Medicine should comprehend *demonstrative* lessons on this important duty.

Whatever distinctions *jurisprudence* may have established with

regard to *homicide*, not only will the proof of the allegation frequently depend upon medical evidence, but sometimes its nature and criminality will be thereby established. The writings of medico-legal authors furnish numerous examples of this nature. In the absence of direct testimony, inferences, drawn from careful investigation, by an intelligent member of the profession, will supply its place; and instances have not been wanting, where unjust or unfounded accusations have, in the same manner, been disproved.

The various ways in which life may be destroyed, viewed merely as to the infliction of violence, resolve themselves into the agencies of *poison*, *suffocation*, and *wounds*.

The first of these involves a very important and peculiar study; one that has of late assumed, in a manner, the rank of a distinct science, and one that, it has been accurately observed, can nowhere be adequately taught, but as part of a course of Forensic Medicine. Recent and interesting discoveries, with regard to articles long known as poisons, have introduced us to an acquaintance with means of cure, and particularly of detection, under the most difficult circumstances, that, until very lately, were unknown; in consequence of which the resources of the practitioner have been enlarged, the safety of the community has been promoted, and the verification of guilt rendered certain, in spite of the most studious attempts to conceal it. This is no small recommendation of itself, in behalf of the study of legal medicine; for in the matter of *poisoning*, there has been more discrepancy among medical witnesses, than on all other topics, on which their testimony has been sought, put together.

In the consideration of death by *suffocation*, a number of interesting facts must necessarily be brought forward, that can claim due attention in no other course of instruction; and with regard to *wounds*, and other modifications of mechanical violence, the prominent point for the consideration of the jurist being their mortality, (whether absolute, relative, or occasional,) a view of an unusual nature, respecting a most important and extensive source of personal injury, will necessarily present itself. The

cure of wounds essentially forms the object of attention to the surgeon, while in courts of law their *curability* will be but an incidental point for investigation.

The discrimination between the evidence of *assassination* and of *suicide*, has not unfrequently been left entirely to the resources of medical knowledge ; and the importance of the question is so great as to render the study of physical circumstances which bear upon it imperative. The death of an individual by his own hand, may involve his reputation only as far as the culprit is concerned ; but as the law, in cases of *self-murder*, i. e., of *felonious suicide*, reaches those who were in no way parties to the crime, by the confiscation of the property of the deceased, it not only becomes a matter of great importance to establish the *plea in bar*, of insanity, but there may be an issue whether the deceased laid violent hands upon himself, or whether this may not have been done by another ; while, on the contrary, allegations may be advanced against innocent persons, in cases where the deceased has been *felo de se.* Throughout the investigation of the foregoing topics, the indications whence medical jurists may draw their inferences as to these points will demand notice; but a separate discussion of the subject of self-destruction forms a necessary article in all treatises and courses of instruction on Forensic Medicine.

Next in order follows an intensely interesting topic, *viz.*, the destruction of one's own offspring, comprehending the crimes of procuring abortion, and the murder of new-born children. Medico-legal writers have designated the former *fœticide*, and the latter *infanticide*, but as these two modifications morally differ no further than as regards the period of existence at which the offspring is made the subject of violence, while, in both instances, the culprit is the parent, Dr. Smith has introduced the comprehensive term *prolicide* as the generic designation of both. The physical relations of the matter differ considerably, the proofs of the crime of infanticide being of a very peculiar nature, wrapped in some obscurity (upon which the indolence and ignorance of medical men have thrown unwarrantable discredit), and absolutely leading to the acquittal of every prisoner now arraigned at the English bar upon the charge of child-murder. Erroneous and

severe (if not unjust) notions were long too prevalent as to the morality of these cases, and a careful consideration of their physical bearings has done much to correct opinions on the point; but a prevalent mistake seems to be at present in high favour in the judiciary quarter, as to the import of those proofs (of a scientific nature), upon which alone conviction can, in almost every case, be grounded.

The question denominated *survivorship*, relates to cases of a plurality of deaths, at the same time, from some common cause, in which it may be of great importance, in the settlement of inheritance, to decide which of the parties may have last perished. This decision must hinge entirely upon physical evidence, and a variety of considerations must be taken into account, both as forming general principles for decision, and as being applicable to particular cases. Under this head will fall to be considered the evidence in some cases of claim under the "tenancy by curtesy" of the English law, and certain other problems, examples of which have been already furnished, even in the courts of this country, illustrative of the subject.

This concludes the first section of the forensic division of the course—comprehending most of the medical business of the criminal courts: the remaining topics chiefly relating to actions for injuries, &c., unconnected with the issue of death.

On Thursday the 16th of February, *A Course of Lectures on Pneumatics, Hydrostatics, and Hydraulics*, was commenced by Robert Addams, Esq.

Four lectures of this series have already been delivered. The first of which consisted of illustrations relating to the resistance, equilibrium, and pressure of aëriform fluids. In the second lecture, the construction of different kinds of barometers, and their application to the measurement of altitudes, were shewn and explained.

Various experimental proofs of the air's elasticity, and the great power which it exercises when in a condensed state, formed the practical part of the third lecture.

In the next, the influence of heat in diminishing the specific

gravity of the air was considered, and which led to an investigation of the ascent of heated air in chimneys, together with the construction of fire-places. The prevention of smoke, and the methods of condensing the sublimed matter in certain metallurgic processes; different plans of warming and ventilating of buildings, were exhibited by models and drawings.

These lectures will be followed by others explanatory of the meteorological phenomena of the atmosphere; also of the theory of sound and harmony.

It is proposed to begin the second division of the course with an examination of the physical characters and conditions of such fluids as are the subjects of hydrostatical inquiry; treating of the laws which regulate their equilibrium and pressure. The importance and application of these laws in the construction of reservoirs, embankments, canals, &c., will be pointed out. After which, the principle, construction, and applicability of hydraulic machines will constitute subjects for discussion.

The course will terminate with some demonstrations of the power of steam, and of the manner in which it is applied to useful purposes.

On Thursday, 2d March, Dr. HARWOOD began his lectures on the *Natural History of the Animal Kingdom*, comprehending a survey of the classes Mammalia and Birds, and of their most remarkable extinct Fossil Genera.

The following is the syllabus of his course:—

Lecture I. *March* 2. Introductory Observations—Classific Arrangements—Grand Division of the Animal Kingdom—Characters of the Mammalia—General Survey of their Bony Fabric—Their Division as improved by Cuvier. *Order* 1*st.*, The QUADRUMANA—The Ape tribes—Diversified adaptations in form and structure to natural habits and economy in the most remarkable genera, *e. g.* Oran-Otans—Gibbons—Monkeys of the Old World—Baboons—American tribes—Genus Ouistitis—Physiognomical differences—Provisions in favour of their young—Precautions for Safety—Faculty of Prehension, &c.

Lecture II. *March* 9. The QUADRUMANA continued—Lemurs—Loris, Galago, &c. *Order* 2*d.*, The CARNIVORA—The Cheiroptera—Bats—Remarkable Mechanism of their instruments for flight—Perfection

of the faculty—Variety in Habits—Acuteness of their sense of hearing—Fossil Animals allied to them—Other Insectivorous Quadrupeds—their teeth—Provisions observable in the Mole—Bears—Diversity in Habits and Intelligence—Peculiarities of Polar Species—Other Plantigrade Quadrupeds—Raccoons, Coatis, &c. The Digitigrada—Characters of the more truly Carnivorous Quadrupeds—their teeth—Relative powers of destruction—Weasel Genus—Pole Cat, Ermine, &c.—Structure adapted to a peculiar mode of Attack—The Canine tribes—Perfection of their Organs and Sense of Smelling—Superior Intelligence—Wolves—their wide Distribution, &c.

Lecture III. *March* 16. The CARNIVORA continued—Jackals—the probable source of our Dogs—their Manners—Susceptibility of Domestication—Dogs—their Superior Intelligence and its important results—Peculiarities in Qualification and Construction observable in some varieties—Foxes—their Economy and nocturnal Organization—Civets—Ichneumons—Hyænas—Habits and extraordinary power of their jaws and teeth—their numbers in many parts of the Old World—Feline Animals—their Sanguinary Character—Formidable Weapons—other Peculiarities and Provisions in their favour—Lions—Tiger—American Species of the Genus Felis—its Geographical Distribution—Domestic Cat.

Lecture IV.* *April* 4. The CARNIVORA continued—Amphibious Mammalia—Seals—their advantageous Formation—Skeleton—Physiognomy—Intelligence—Senses—Frequency on our own Coasts—Walrus—Peculiarities in Structure and Habits—Extinct Fossil Species of the Order Carnivora—Caves containing their remains—Manner in which they are deposited in those of Germany—Similar depositions in Great Britain—Cave at Kirkdale—Characters of the Marsupial Animals—Opossums—Kangaroos—Koala—Wombat. *Order 3rd.*, The RODENTIA—Advantageous Arrangement and Structure of their teeth for gnawing hard substances—Beavers—The Rat Genus—Varieties it presents in Economy—their Migrations—Deposits of Food—Jerboas—Marmots—their Torpidity—Porcupines—Hare and Paca Genera—Fossil Species of the Order.

Lecture V. *April* 13. *Order 4th.*, The EDENTATA—Slow-moving Quadrupeds—Sloths—Ant-Eaters—their Anomalous Formation and Economy—Manis—Armadillos—Ornithorhynchus and Echidna Genera—their Peculiarities—Gigantic Fossil American Animals of this Order—Hoofed Quadrupeds. *Order 5th.*, The PACHYDERMATA—Elephants—Living Species—Natural Manners—Advantageous formation of their teeth—Arrangement of Enamel in several Animals of the Order, affording useful Generic Distinctions—Fossil Elephants—their Wide Distribution—Characterize the Deposits of the Deluge—Abundance in the North of Europe—Tungusian entire Skeleton—Mastodons.

* These lectures are to be continued from this period, on Tuesday evenings.

Lecture VI. *April* 18. The Pachydermata continued—Hippopotamus—at present confined to Africa—Species found Fossil in Europe—the Hog Genus—Peccary—Sus tajaçu—Babirroussa—other Lost Genera of the Pachydermata—Anaplotheria—Rhinoceros—its Peculiarities in Form and Habits—Living and Lost Species, the latter common in Great Britain—Taper Genus—Newly-discovered Living Eastern Species—Antediluvian Animals of the Order.—The Solipedes—the Horse—Habits and qualifications of this important Genus—its principal varieties—Quagga—Zebra—Ass.

Lecture VII. *April* 25. *Order 6th.* The Ruminantia—Characters of the Animals it comprises—Provisions in their Favour—Camels—Peculiar Adaptations in their Structure to their mode of Life—Musks—Deer—Fall and rapid Growth of their Antlers—Fossil Deer—Irish Elk—great size of this lost Species—Skeleton discovered in the Isle of Man—Giraffe—the Antelope Genus—Gazelle—Chamois—Gnou—Goats—Ibex—Cashmere and other Domestic Varieties—Curious Effects of Long Dependance in this and the following Genus—Argali—Mouflon—Domestic Sheep—Most remarkable or important Foreign and British Varieties.

Lecture VIII. *May* 2. The Ruminantia continued—Ox Genus—its wide dispersion—European Buffaloes—Wild Cattle of South America—Musk Ox—Bison—Domestic Varieties of Ox—most remarkable or useful British Races—Indian Variety—Gigantic Antediluvian Species of the Genus.—*Order 7th.*, The Cetacea—Peculiarities in the Structure of the Whale tribe—its relation to the present Class—Form of the Skeleton—Herbivorous Genera—the Manati and Duyongs—their Intelligence and Habits—Dolphins—Porpoises—Grampus—Narwhale—the True Whales—their Forms, Senses, and natural Manners—Cachalots—Beaked Whale—Common Whale—Whaling.

Lecture IX. *May* 9. Class 2d. Birds.—Their General Characters—Beautiful Adaptation in Form and Structure to their Peculiar Habits and Destinies—Analogies in Conformation to that of Quadrupeds—Bony Fabrick—Interesting Modifications it exhibits—Variety of Form in its separate Parts—General Economy—Cuvierian Improvements in the Linnæan Arrangement adopted in this Class. *Order 1st.*, Accipitres—their Distinctive Peculiarities and natural Manners—Perfection of their Vision —Vultures — Condor — Serpentarius — Falcon Genus—Eagles—British Species—their Nidification—True Falcons—Short-winged Kinds—Owls—their Sense of Hearing—British Species.

Lecture X. *May* 16. *Order 2nd.*, Passeres—Examples of Curious Nidification—Diversity of Economy in favour of their Young—Peculiarities in Structure and Habits of several Genera of this and the following Order—the Dentirostres—Butcher Birds, Thrushes, &c,—Migration—Vocal Organs and Faculties—Fissirostres—Swallows—Nest of Javan Species—Goatsuckers—Conirostres—Crows, Ravens, Birds of Paradise,

&c. — Tenuirostres — Humming Birds, Creepers, &c.—Syndactyles—Hornbills, Kingfishers, &c. *Order 3d.*, The SCANSORES or Climbers—Parrots, Toucans, Woodpeckers, &c. *Order 4th.*, The GALLINÆ—Poultry—their Structure designed for a Vegetable Diet—Peacock, Alector, Pheasant, Partridge, Grouse, and Pigeon Genera.

Lecture XI. *May* 23. Difference observable in the flight of Birds, affording to the practical Naturalist Criteria distinctive of Genera—relative Power of their Wings—Position of their Feet, &c. *Order 5th.*, GRALLÆ—Energy of their Senses—Peculiarities in the Formation and Economy of particular Genera and Species—The Brevipennes—Ostriches Cassowaries, &c.—The Pressirostres—Bustards, Plovers, &c.—the Cultrirostres—Wading Birds—Cranes, Herons, Storks, Bitterns, &c.—the Longirostres, Curlews, Woodcocks, Snipes, Himantopus.—The Macrodactyles, Coots, Moorhens, Jacanas, &c.

Lecture XII. *May* 30. Clothing of Birds—its Varieties. *Order 6th.*, PALMIPEDES—Swimming Birds—Beautiful Adaptations in their Formation to their Habits and Economy. The Diving Birds—Diving—Grebes, Divers, Auks, Penguins—Peculiarities in their Structure—the Longipinnes—Petrels, Albatross, Gulls, Terns—the Totipalmes—Pelicans, Cormorants, Gannet. Tropic Birds—Nidification—the Lamellirostres—Swans, Ducks, Geese, Mergansers—remarkable Formations of the Organs of Voice in several Genera—Fossil Remains of the Class—Conclusion of the Course.

Proceedings at the Meetings *of the Members* of the *Royal Institution*, held every *Friday Evening*, during the Season.

Friday, February 3d. The members held their first weekly meeting at half past eight o'clock. In the lecture-room were exhibited a great variety of specimens of caoutchouc or elastic gum in all its states, from the uncoagulated crude sap of the tree to that of perfect purity and aggregation, and also as united to various fabrics, producing a variety of strong, flexible, and perfectly water-tight materials, some being of extreme delicacy, and others of great thickness and strength. These were furnished for the occasion by Mr. Thomas Hancock, who has had peculiar opportunities of manipulating with this substance, and possesses the knowledge of a process by which it can be rendered fluid, and yet retain the power of hardening and assuming its elastic state again. Mr. Faraday explained the nature of caout-

chouc, and gave the results of an analysis of the unchanged sap. The various specimens of cotton, silk, linen, leather, felt, woollen, &c., which were upon the table, had been rendered water-tight by the intervention of a layer of caoutchouc between two layers of the fabric, as for instance, cotton or silk, and the adhesion was so perfect, that the substance seemed but as one web. The perfect retention of water by these substances was shewn by a calico bag, into which a quart of water had been introduced, and the opening closed up; not a drop or particle of moisture could be perceived on the exterior, though the bag was much handled and pressed.

When several folds of calico, linen, or canvass were cemented together by this substance, a material was produced answering many of the purposes of leather, and surpassing it in value, in numerous applications. Its use in the construction of the connecting bands for machinery and card fillets have been tried and approved of.

In consequence of the manner in which the caoutchouc is applied, no limit occurs as to the form, or size, or delicacy, or strength of the water-tight vessels or things which may be made: it is equally applicable to the cloak and the caravan cover, to the most ornamented flower vase, and the strongest water-bucket.

For further information respecting the chemical history of this substance, see page 19, of the present volume.

Friday, February 10*th.* This evening the results obtained by Mr. Brunel during three years of exertion in endeavouring to apply the liquids resulting from the condensation of the gases as mechanical agents, were brought forward by Mr. Faraday in the lecture-room, and illustrated by drawings from Mr. Brunel's office That the gases had been condensed in the laboratory of the Instition, had been before stated to the members, and the general process and results were again briefly referred to. Mr. Brunel selected carbonic acid as the substance best adapted for the important purposes to which he wished to apply it, namely, the construction of an engine which should rival in power and utility

the steam-engine. His experiments have thus far been directed to an investigation of the powers of the agent, and the results were very favourable. The elasticity of the vapour was found equal to 60 atmospheres at 50°, and 120 atmospheres at 90°. He had been able ultimately to make the junctions of his apparatus perfectly tight at these high pressures, had produced quantities of liquid carbonic acid, amounting to a pint and a-half, and further, had been able so to arrange his apparatus, as to confine the substance even at the highest temperature by tubes of brass not above the $\frac{1}{30}$ of an inch in thickness, combining perfect security with the power of readily increasing or diminishing the temperature of the liquid. Having obtained the most satisfactory results with the first apparatus, an engine is now in progress which is to have in the working cylinder, a piston six inches diameter, and of four feet stroke.

As an illustration of the power of the agent, certain glass tubes upon the table, containing portions of carbonic acid, were referred to; they were about eight inches long, and 0.3 of an inch internal diameter; the pressure upon their internal surface equalled 8000lbs. Notwithstanding this power, not a single accident has happened in Mr. Brunel's experiments.

A plant of the ficus elastica of Linnæus, one of those from which caoutchouc may be obtained, was shewn to the members in the library by Mr. Frost.

Friday, February 17th. On this evening Mr. T. Griffiths' experiments relative to the state of the alkali in glass, were illustrated in the Library. Glass being pulverized in a clean wedgewood or agate mortar, and placed in a little heap on turmeric paper, was moistened with pure water, and in consequence of the action of the water on the glass, an alkaline solution was immediately produced, which deeply stained the turmeric paper. This decomposition of the glass is entirely superficial, and glass powder, which by repeated washing had lost this property, regained it by the production of fresh surfaces, by further pulverization. (See Vol. XX, p. 259, of this Journal.)

Mr. Cornelius Varley was also present with his microscope, which is peculiar in the facility with which the object is moved and brought into the focus of the lens. The instrument was a single microscope, and the facility with which the adjustments could be made, was shown by the ease with which all the motions of a small water insect could be followed. Mr. Varley also had a lens, unique in its kind, being made out of a diamond, and which was shewn to have very high powers. In consequence of a flaw in the interior of the diamond not discovered or discoverable till some month's labour had been given to it, it was not finished; but the operations are to be renewed on a fresh gem.

Mr. Brant sent for the inspection of the members, an extraordinary large bar of palladium, weighing above six pounds, which he had received from the Province or County of Sergipe, near the river S. Francisco, in the Brazils. The correct history of the new source of this metal is not as yet known.

An interesting geological and mineralogical series of specimens from South America were also put upon the tables.

Friday, February 24th. Mr. C. Varley explained in the lecture-room the nature and construction of his graphic telescope, an instrument intended to perform the offices of that beautiful invention, the *camera lucida*, at the same time that it permits of using magnifying powers, and, consequently, of drawing or sketching objects at a distance too small or too confused to be appreciated by the naked eye. The various difficulties which occurred, and the manner in which they were overcome, were stated, and the powers of the instrument afterwards illustrated in the library, by being directed to objects present, and by numerous drawings made with it.

A series of dissected leaves, flowers, and fruits were also laid upon the tables, showing the delicate skeletons of woody fibre, upon which the pulpy and soft parts of vegetables are deposited and supported.

Friday, March 3d.—The subject for illustration this evening

was LITHOGRAPHY. Mr. HULLMANDELL, of Great Marlborough-street, sent numerous specimens of the different styles producible by this art, and was good enough also to furnish stones in various states, to etch and print from them in the lecture-room, and also to transfer writing from paper to stone; whilst the nature of the materials employed, and the general theory of the processes were explained, by Mr. FARADAY. The general process consists in drawing the design upon the stone with a soapy chalk, in decomposing this soapy design by an acid which, liberating the fatty matter present, greases the stone where the design existed, or rather brings it into such a state that, being wetted and then rolled with the ink-roller, no ink will adhere except at the parts underneath the original design. The peculiar power of the stone, which, though wet all over, will adhere to the ink in these parts only, and in such quantity as to preserve perfectly the keeping of the drawing, was pointed out, and the various styles illustrated.—These are

Chalk drawing; including *dabbing*.
Pen and ink drawing.
Engraving on the stone.
Transfers, either from a writing or drawing, or from impressions taken from copper-plates, engraved blocks, &c.

Numerous fine impressions of each style were afterwards exhibited and explained by Mr. Hullmandell in the library.

On Friday evening, the 10*th of March*, Mr. BRANDE submitted to the meeting some remarks upon the composition of genuine port wine, as opposed to that of the port wine usually met with in this country. Two samples were exhibited—one of the vintage of 1824, and one which had been 10 years in bottle: the taste of the wine is rich and sweetish, having more of the flavour of Rousillon, or of some varieties of Cote Roti, than of ordinary port; it is also more subject to a slight secondary fermentation, if not kept in a cool cellar and well corked. The average proportion of alcohol in the common port wines is at least 22 per cent.; but of these samples the old wine in bottle afforded only

16 per cent., and the new scarcely 17. Some very old hock (probably 80 years in bottle) was also examined, and was found to contain between 15 and 16 per cent. of alcohol, a quantity exceeding the usual average found in the generality of samples of that wine.

Mr. Brande then proceeded to shew and to explain the various modes of determining the strength of wines, and pointed out the important use of Mr. Gilpin's Tables, published in the *Philosophical Transactions* for 1794, in inquiries of this nature: he also offered some remarks upon the probable causes of the very different effects of different wines upon the constitution, independent of the quantity of alcohol which they include, and upon the mischievous effects of spirituous liquors, or products of *distillation*, as compared with vinous liquors, or products of *fermentation.*—He concluded with a brief account of the principal changes which wine suffers in bottle, and of the alterations effected in it by long keeping in the cask, more especially in warm climates.

Friday, March 17th.—This evening was devoted to the subject of Copper-plate Engraving and Printing, which was practically and theoretically illustrated and explained by Mr. TURRELL. The processes of etching, and biting in, with an account of the various materials and implements used in those processes, and of the best modes of applying them, were the principal subjects brought before the meeting; and a variety of beautiful specimens of the art, shewing the varied effects producible by different modes of proceeding, were placed upon the table. Mr. Turrell prefaced the practical part of his subject with some historical details, in the course of which he took an opportunity of paying a warm tribute of applause to the exertions of the late Mr. Lowry.

[These Meetings were adjourned to Friday the 7th of April, on account of the intervention of Easter.]

ART. XIII. ASTRONOMICAL AND NAUTICAL COLLECTIONS.—No. XXII.

i. *A brief Investigation of the Properties of the* GEODETIC CURVE. *By the* EDITOR.

PROFESSOR BESSEL has lately premised to his very elaborate and refined computations of latitudes and longitude, on a spheroid, a demonstration of the elementary property of the curve of shortest distance, founded, as he says, on the theorem of *Taylor*, which affords him, for U', a value of U corresponding to $\varphi + z$, as a value of φ, z being a function of w, the expression "$U + \left(\frac{\mathrm{d}U}{\mathrm{d}\varphi}\right) z + \left(\frac{\mathrm{d}U}{\mathrm{d}p}\right) \frac{\mathrm{d}z}{\mathrm{d}w} + \ldots$" This may indeed be perfectly correct: but it would probably have surprised Dr. Brook Taylor not a little to see himself made responsible for such an inference: which it would have cost him much more labour to comprehend than it did to invent his theorem: and it would have staggered him most of all to see his finite increment "h" converted into a new flowing quantity z, and having a distinct fluxion assigned to it.

The true and natural method of solving these problems, and by far the simplest and most intelligible, is to use a separate notation for the variation of the curve, in its transition into another neighbouring curve: and, for a spheroid of rotation, the variation may be most conveniently supposed to be effected by the elementary removal of the points along the same parallels of latitude only, so that the curvature of the elements of latitude and longitude may remain unaltered.

Thus, if x be the angular latitude, y the longitude, and s the linear distance, R being the radius of the meridian, and r that of the parallel of latitude: we shall obviously have (1) $\mathrm{d}s^2 = R^2 \mathrm{d}x^2 + r^2 \mathrm{d}y^2$; and hence, following exactly the steps of the Illus-

trations of Laplace, N. 289, Sch. 2, P. 152, we have $\delta ds = \frac{rrdy\delta dy}{ds}$, since $\delta x = 0$; and since $d\left(\frac{r^2 dy}{ds}\delta y\right) = \frac{r^2 dy}{ds} d\delta y + d\frac{r^2 dy}{ds}\delta y = \frac{r^2 dy}{ds}\delta dy + d\frac{r^2 dy}{ds}\delta y$, we have $\int \delta ds = r^2 \frac{dy}{ds}\delta y - \int d\frac{r^2 dy}{ds}\delta y = \delta s$. Now in order that the distance may be the shortest possible, this fluent, taken between the extreme points of the curve, must vanish; and at each of these points the variation δy must wholly vanish, although it is supposed at the intermediate points to have a value comparable to the other varying elements: consequently the second part of the fluent, $\int d\frac{rrdy}{ds}\delta y$, must be every where $= 0$, since it cannot have alternately positive and negative values consistently with the required property of the curve, which must everywhere be the shortest possible: and this can only happen when $d\frac{rrdy}{ds} = 0$, and $r^2\frac{dy}{ds}$ is a constant quantity. But $\frac{rdy}{ds}$ is the sine of the inclination of the curve to the meridian, which must therefore be inversely as r the radius of the parallel of latitude, in order that $r\frac{rdy}{ds}$ may be constant. Mr. Fog Thune, assisted by Professor Bessel, has investigated the curve more generally, by the method of variations, in his Spheroidical Trigonometry, without limiting it in the first instance to a spheroid of rotation. We may now proceed to Professor Bessel's latest computations.

ii. *Calculation of Geographical* LONGITUDES *and* LATITUDES *on a Spheroid. By* Professor BESSEL, *Knight.* Astr. Nachr. N. 86.

2.

SUPPOSING the initial azimuth of the curve at the point A, reckoned eastwards from the north, to be α', and the distance of A from the axis to be r', we have $r' \sin. (\alpha' + 180°) = r \sin. \alpha$, r and α being the distances and azimuths at any other point of the curve, or (2) . . . $r' \sin. \alpha' = - r \sin. \alpha$.

3.

Let the greatest radius of the spheroid be a, then r and r' are not greater than a, and we may take an angle u, such that $r' = a \cos. u'$ and $r = a \cos. u$: so that the equation (2) may assume the form (3) . . $\cos. u' \sin. \alpha' = - \cos. u \sin. \alpha$. This equation expresses the relation between two sides of a spherical triangle $90° - u'$ and $90° - u$, with the angles opposite to them $360° - \alpha$ and α'. The third side of this spherical triangle, and the angle opposite to it, which I shall designate by σ and ω, afford us, when introduced into the computation, some elegant expressions for the corresponding variations of s, u, and the longitude w. We obtain, for example, by means of the well known theorems for the fluxions of spherical triangles, $du = - \cos. \alpha d\sigma$;

$\cos. u d\omega = - \sin. \alpha d\sigma$; and substituting these expressions in the values of ds, that is the latitude being φ,

$$ds \cos. \alpha = - R d\varphi = \frac{dr}{\sin. \varphi}, \text{ and}$$

$$ds \sin. \alpha = - r dw;$$ expressing also r by means of u, we have

$$(4) \begin{cases} ds = a \dfrac{\sin. u}{\sin. \varphi} d\sigma; \\ dw = \dfrac{\sin. u}{\sin. \varphi} d\omega. \end{cases}$$

[It may be observed that, in a sphere, we have $\sigma = s$, and $\omega = w$. ED.]

4.

I shall now suppose the meridians to be truly elliptical, and shall express their greater semi-axis by a, the lesser by b, and the eccentricity by e. Taking the fluxion of the equation of the ellipsis for the co-ordinates x and y, that is $1 = \frac{xx}{aa} + \frac{yy}{bb}$, and putting $-\cot.\varphi$ for $\frac{dy}{dx}$, we have $0 = \frac{x \sin.\varphi}{aa} - \frac{y \cos.\varphi}{bb}$; and by the combination of the two equations $x = \frac{a \cos.\varphi}{\sqrt{(1 - ee \sin.^2\varphi)}}$. Now this x is the r of the present computation, and consequently equal to $a \cos. u$; whence $\cos. u = \frac{\cos.\varphi}{\sqrt{(1 - ee \sin^2\varphi)}}$; $\cos.\varphi = \frac{\cos. u\sqrt{(1-ee)}}{\sqrt{(1 - ee \cos.^2 u)}}$; $\sin. u = \frac{\sin.\varphi \sqrt{(1-ee)}}{\sqrt{(1 - ee \sin.^2\varphi)}}$; $\sin.\varphi = \frac{\sin. u}{\sqrt{(1 - ee \cos.^2 u)}}$; $\text{tang.}\, u = \text{tang.}\,\varphi \sqrt{(1-ee)}$; $\text{tang.}\,\varphi = \frac{\text{tang.}\, u}{\sqrt{(1-ee)}}$; and $\frac{\sin. u}{\sin.\varphi} = \sqrt{(1 - ee \cos.^2 u)}$.

If we substitute these values in those of the fluxions (4), we have, for an elliptic spheroid of rotation,

$$(5)\quad \begin{cases} ds = a\sqrt{(1 - ee \cos.^2 u)}d\sigma, \\ dw = \sqrt{(1 - ee \cos.^2 u)}d\omega. \end{cases}$$

5.

In order to integrate the first of these expressions, I shall change the three equations between u', u, α', α, and σ.

$$(6)\quad \begin{cases} \sin. u = \sin. u' \cos.\sigma + \cos. u' \sin.\sigma \cos.\alpha' \\ \cos. u \cos.\alpha = \sin. u' \sin.\sigma - \cos. u' \cos.\sigma \cos.\alpha' \\ \cos. u \sin.\alpha = - \cos. u' \sin.\alpha'; \end{cases}$$

by the introduction of the subsidiary angles m and M, which are such that

$$(7)\quad \begin{cases} \sin. u' = \cos. m \sin. M \\ \cos. u' \cos.\alpha' = \cos. m \cos. M \\ \cos. u' \sin.\alpha = \sin. m; \end{cases}$$

they will then become

$$(8)\begin{cases}\sin. u = \cos. m \sin. (M+\sigma)\\ \cos. u \cos \alpha = -\cos. m \cos. (M+\sigma)\\ \cos. u \sin. \alpha = -\sin. m.\end{cases}$$

Hence we obtain

$$\cos.^2 u = 1 - \cos.^2 m \sin.^2 (M+\sigma)$$

and

$$(9) \quad \ldots\ldots \; ds = a \sqrt{\{1 - ee + ee \cos.^2 m \sin.^2 (M+\sigma)\}} d\sigma.$$

The integral of this expression depends on the rectification of the ellipsis, and is given by *Legendre*, in his Exercices du Calcul Intégral. But the means of computing the elliptical transcendents have not yet attained the perfection and facility that would enable them to supersede the developement of the result in the form of a series, which shall converge rapidly when ee is very small; and this object may be the most readily attained by the resolution of the quantity under the radical sign into two imaginary factors ; thus

$$ds = \tfrac{1}{2} a d\sigma \{\sqrt{(1 - ee \sin.^2 m)} + \sqrt{(1-ee)}\} \{1 - \varepsilon c^{2i(M+\sigma)}\}^{\frac{1}{2}}$$
$$\{1 - \varepsilon c^{-2i(M+\sigma)}\}^{\frac{1}{2}} ; \text{ making hlc} = 1, \; i^2 = -1,$$

and $\varepsilon = \dfrac{\sqrt{(1-ee \sin.^2 m)} - \sqrt{(1-ee)}}{\sqrt{(1-ee \sin.^2 m)} + \sqrt{(1-ee)}}$; [and recollecting that $2i \sin. (M+\sigma) = c^{i(M+\sigma)} - c^{-i(M+\sigma)}$. Illustr. Art. 358.]

If we now put $\dfrac{e \cos. M}{\sqrt{(1-ee)}} = \text{tang.} E$, we have $\varepsilon = \text{tang.}^2 \tfrac{1}{2} E$,

and $ds = a \sqrt{(1-ee)} \dfrac{\cos.^2 \frac{1}{2} E}{\cos. E} d\sigma \sqrt{(1 - \varepsilon c^{2i(M+\sigma)})} \cdot \sqrt{(1 - \varepsilon c^{-2i(M+\sigma)})}$

By resolving the two factors under the radical sign into infinite series, and multiplying them together, we obtain

$$ds = a \sqrt{(1-ee)} \frac{\cos.^2 \frac{1}{2} E}{\cos. E} d\sigma \{A - 2B \cos. 2(M+\sigma) - 2C \cos. 4(M+\sigma)$$
$$- 2D \cos. 6(M+\sigma) - \ldots\}$$

: the letters $A, B, C \ldots$ expressing the sums of infinite series, thus

$$A = 1 + \left(\frac{1}{2}\right)^2 \varepsilon^2 + \left(\frac{1.1}{2.4}\right)^2 \varepsilon^4 + \left(\frac{1.1.3}{2.4.6}\right)^2 \varepsilon^6 + \ldots$$

$$B = \frac{1}{2}\varepsilon - \frac{1.1}{2.4} \cdot \frac{1}{2} \varepsilon^3 - \frac{1.1.3}{2.4.6} \cdot \frac{1.1}{2.4} \varepsilon^5 - \frac{1.1.3.5}{2.4.6.8} \cdot \frac{1.1.3}{2.4.6} \varepsilon^7 - \ldots$$

$$C = \frac{1.1}{2.4}\varepsilon^2 - \frac{1.1.3}{2.4.6}\cdot\frac{1}{2}\varepsilon^4 - \frac{1.1.3.5}{2.4.6.8}\cdot\frac{1.1}{2.4}\varepsilon^6 - \frac{1.1.3.5.7}{2.4..10}\cdot\frac{1.1.3}{2.4.6}\varepsilon^8 - \ldots$$

And the fluent, beginning from $\sigma = 0$, will be

$$(10)\ldots\ s = b\,\frac{\cos.^2\frac{1}{2}E}{\cos.E}\left\{A\sigma - 2B\cos.(2M+\sigma)\sin.\sigma - \frac{2}{2}C\cos.(4M+2\sigma)\sin.2\sigma - \frac{2}{3}D\cos.(6M+3\sigma)\sin.3\sigma - \ldots\right\}$$

6.

We obtain, by means of this series, the distance s of the points A and B, expressed in terms of u', α', and σ; if, on the contrary, we have determined s and α' by observation, u' being known from the latitude of A, we may find σ by the solution of the transcendent equation here laid down: and the latitude of the point B, together with the direction of the geodetical line at its termination there, will be determined by the equation (8). The resolution of the transcendent equation may be effected, either by the reversion of the series (10), or by successive approximations: but the latter mode is the more convenient, with the assistance of the tables subjoined to this essay.

For this purpose I make

$$(10)\ \ldots\sigma = \frac{\alpha}{b}s + \beta\cos.(2M+\sigma)\sin.\sigma + \gamma\cos.(4M+2\sigma)\sin.2\sigma + \ldots;\ \text{making}$$

$$\alpha = \frac{648000}{\pi}\cdot\frac{\cos.E}{\cos.^2\frac{1}{2}E}\cdot\frac{1}{A}$$

$$\beta = \frac{648000}{\pi}\cdot\frac{2B}{A}$$

$$\gamma = \frac{648000}{\pi}\cdot\frac{C}{A}$$

$$\delta = \frac{648000}{\pi}\cdot\frac{2.D}{3.A};\ \text{and so forth.}$$

The tables contain the logarithms of α, β, γ; and are so arranged, that their argument is log. $\frac{e \cos. m}{\sqrt{(1-ee)}}$. By this arrangement, we obtain the advantage, that the numbers of the table, for log. β, increase very nearly by the double difference of the arguments, and in the table for log. γ, by the quadruple difference: a circumstance which greatly facilitates their employment.

We take $\frac{\alpha s}{b}$ as the first approximate value of s, and substituting it in the second term of the expression, we obtain a second approximation, to be again substituted in the second, and to be employed in the third term. The convergence of the series is so great, that taking the argument even 9.1, which is only possible with an ellipticity greater than $\frac{1}{128}$, the approximation never requires to be carried further, even to give σ within $''.001$ of the truth: the addition depending on δ amounting, even in this case, only to $''.0001$.

7.

The table for log. α is carried to 8 places of decimals: an error of half a unit in the last decimal occasions only when σ is as great as 12° 4′, or when the distance is about 700,000 toises, an error of $''.0005$, answering to .008 toise. For the same value of σ we may compute with the table for log. β, if we use all the decimals in the table, with a still greater degree of precision; and as a greater degree of accuracy is superfluous, I have carried the table for β to 6 decimals at the end, but in the earlier parts I have only set down as many as would ensure us against an error of $''.0005$, which is much less than must be expected to occur in the most delicate geographical measurements. The third member of the series, for this value of σ, even at the end of the table, is never greater than $''.17$, so that three places of decimals are sufficient for log. γ. The error then, in a distance not exceeding 700,000 toises, will not exceed one thousandth of a second: and even for a quadrant of the earth, the table will not leave a doubt amounting to the hundredth of a second.

8.

In order to illustrate the use of these tables by an example, I shall take the situation of Dunkirk, with relation to Seeberg, as inferred by Lieut. General von Müffling, in the Astr. N. N. 27, from his great trigonometrical operations: they give us

$$\text{Log. } s = 5.47830314$$
$$\alpha' = 274^\circ\ 21'\ 3'',18;$$

and I shall assume for the latitude of the observatory at Seeberg, $\varphi' = 50^\circ\ 56'\ 6'',7$; log. $b = 6.51335464$; and log. $e = 8.9054355$. Then, by the equation, tang. $u' = \sqrt{(1-ee)}$ tang φ', we find

$$\begin{aligned} \text{Log. tang. } \varphi' &= 0.09062665 \\ \sqrt{(1-ee)} &= 9.99859060 \\ \hline \text{tang. } u' &= 0.08921725; \; u' = 50^\circ\ 50'\ 39''.057. \end{aligned}$$

From u' and α' we abtain M, cos. m, and sin m; thus,

$$\begin{aligned} \text{Log. sin. } u' &= 9.88954351 \\ \text{cos. } u' &= 9.80032627 \\ \text{cos. } \alpha' &= 8.88003733 \\ \text{sin. } \alpha' &= 9.99874662\ n \\ \hline \text{cos. } m \text{ sin. } M &= 9.88954351 \\ \text{cos. } m \text{ cos. } M &= 8.68036360 \\ \text{sin. } m &= 9.79907289\ n \\ \hline \end{aligned}$$

$M = 86^\circ\ 27'\ 53'',949$; $2M = 172^\circ\ 55'\ 47'',9$; $4M = 345^\circ\ 51'\ 36''$, log. cos. m 9.89037063: and for the argument of the tables,

$$\text{log. } \frac{e}{\sqrt{(1-ee)}} \text{ cos. } m; \quad \text{log. } \frac{e}{\sqrt{(1-ee)}} = 8.906845$$
$$\text{cos. } m = 9.890371$$
$$\text{Argument } \quad 8.797216$$

With this argument we obtain, from the table, the logarithm of α, which gives us $\frac{\alpha}{b}s$; thus

$$\begin{aligned} \text{log. } \alpha &= 5.31399893 \\ b, \text{A. C.} &= 3.48664536 \\ s &= 5.47830314 \\ \hline \frac{\alpha}{b}s &= 4.27894743; \quad \frac{\alpha}{b}s = 5^\circ\ 16'\ 48'',482. \end{aligned}$$

Taking this as the first approximation to the value of σ, we find

the second, by the addition of the second term of the series (11):

$$\begin{array}{ll} \text{Log. } \beta & = 2.30595 \\ \cos.\ (2M+\sigma) & = 9.99979\ n \\ \sin.\ \sigma & = [8].96391 \\ \hline & 1.26965\ n; \ = -\ 18''.60. \end{array}$$

The more accurate computation of this term, with the second approximation of $\sigma = 5^\circ\ 16'\ 29'',9$, together with the third term, affords

$$\begin{array}{ll|ll} \text{Log. } \beta & = 2.30595 & \text{Log. } \gamma & = 8.395 \\ \cos.\ (2M+\sigma) & = 9.99979\ n & \cos.\ (4M+2\sigma) & = 9.999 \\ \sin.\ \sigma & = 8.96348 & \sin.\ 2\sigma & = 9.263 \\ \hline & 1.26922\ n & & 7.657 \end{array}$$

$$= -\ 18''.587 \quad . \quad . \quad . \quad . \quad . \quad . \quad +\ 0''.004.$$

We have therefore $\sigma = 5^\circ\ 16'\ 29''.899$, and finally, α, u, and ϕ, from the formulas (8);

$$\begin{array}{ll} M + \sigma = & 91^\circ\ 44'\ 23''.848 \\ \text{Log. sin. } (M+\sigma) & = 9.99979971 \\ \cos.\ (M+\sigma) & = 8.48234932 \\ \cos.\ m & = 9.89037063 \\ \sin.\ m & = 9.79907289 \\ \hline \sin.\ u & = 9.89017034 \\ \cos.\ u \cos.\ a & = 8.37271995 \\ \cos.\ u \sin.\ a & = 9.79907289 \\ \hline \alpha = & 87^\circ\ 51'\ 15'',523; \end{array}$$

$$\begin{array}{ll} \text{Log. cos. } u & = 9.79937750 \\ \hline \text{tang. } u & = 0.09079284 \\ \sqrt{(1-ee)}\ \text{A. C.} & = 0.00140940 \\ \hline \text{tang. } \phi & = 0.09220224;\ \phi = 51^\circ\ 2'\ 12''.719 \end{array}$$

In this example I have carried the logarithms to 8 decimals, because, even in this approximation, α and ϕ are not so accurately determined as the tables for log. α, β, γ admit. If we wished to employ the common logarithmic tables with 7 decimals, the last figures in these tables might be neglected.

9.

We have to find the difference of longitude w, by the integration of the fluxion (5).

$$dw = \sqrt{(1 - \cos.\ ee \cos.^2 u)}\ d\omega$$

But this expression contains two separate co-efficients, m and e, which cannot be combined; so that we cannot reduce the strictly-accurate solution of this problem to tables which are applicable to all values of e. In order, however, to attain this object, it is only necessary to sacrifice so much of this theoretical accuracy as is of no consequence whatever in practical cases.

Putting $dw = d\omega - (1 - \sqrt{ee \cos.^2 u})\ d\omega$, and substituting, for the last $d\omega$, $\dfrac{\sin.\ \alpha' \cos.\ u'}{\cos.^2 u}\ d\sigma$, we obtain $w = \omega - \sin.\ \alpha' \cos.\ u'$ $\displaystyle\int \frac{1 - \sqrt{(1 - ee \cos.^2 u)}}{\cos.^2 u}\ d\sigma$; and making again $\dfrac{1 - \sqrt{(1 - ee \cos.^2 u)}}{\cos.^2 u} = \dfrac{ee}{2}\ (1 + eep \cos.^2 u)^q (1 + y)$, we obtain

$$1 + y = \frac{2(1 - \sqrt{[1 - ee \cos.^2 u]})}{ee \cos.^2 u\ (1 + eep \cos.^2 u)^q} =$$

$$\frac{1 + \frac{1}{4} ee \cos.^2 u + \frac{1}{8} e^4 \cos.^4 u + \frac{5}{64} e^6 \cos.^6 u + \ldots}{1 + qpee \cos.^2 u + \frac{q.q-1}{1.2} ppe^4 \cos.^4 u + \frac{q.q-1.q-2}{1.2.3} p^3 e^6 \cos.^6 u + \ldots}$$

In the denominator of this expression the three first terms will be equal to those of the numerator if we put $p = -\dfrac{3}{4}$ and $q = -\dfrac{1}{3}$; we thus obtain

$$1 + y = \frac{1 + \frac{1}{4} ee \cos.^2 u + \frac{1}{8} e^4 \cos.^4 u + \frac{5}{64} e^6 \cos.^6 u + \ldots}{1 + \frac{1}{4} ee \cos.^2 u + \frac{1}{8} e^4 \cos.^4 u + \frac{7}{96} e^6 \cos.^6 u + \ldots}$$

$= 1 + \dfrac{1}{192} e^6 \cos.^6 u + \ldots$; whence it follows that by neglecting y we introduce an error of the order e^8 only, the greatest effect of this error, in the value of w, being only $\dfrac{1}{384} e^8 \sigma$, and therefore not perceptible even in the computation of very extensive

distances with logarithms to 10 decimals. We may therefore in practice make $y = 0$, and then reduce the fluent to tables which will serve for every value of e.

10.

According to this remark we have

$$w = \omega - \frac{ee}{2}\sin. m \int \frac{d\sigma}{\sqrt[3]{(1 - \frac{3}{4} ee \cos.^2 u)}}$$

$$= \omega - \frac{ee}{2}\sin. m. \int \frac{d\sigma}{\sqrt[3]{(1 - \frac{3}{4} ee \cos.^2 m \sin.^2 [M + \sigma])}}.$$

Then putting $\text{tang.}\, E' = \dfrac{e\sqrt{\frac{3}{4}}\cos. m}{\sqrt{(1 - \frac{3}{4} ee)}}$, and

$$\text{tang.}^2 \frac{1}{2} E' = \varepsilon';$$

the fluent in the second term of the equation becomes

$$\int \frac{d\sigma}{\sqrt[3]{(1 - \frac{3}{4} ee)}\sqrt[3]{(1 + \text{tang.}^2 E' \sin.^2 [M' + \sigma])}}; \text{ or}$$

$$\int \frac{\sqrt[3]{(1 - \varepsilon')^2}}{\sqrt[3]{(1 - \frac{3}{4} ee)}} . \left\{1 - \varepsilon' c^{2i(M+\sigma)}\right\}^{-\frac{1}{3}} . \left\{1 - \varepsilon' c^{-2i(M+\sigma)}\right\}^{-\frac{1}{3}} d\sigma$$

Then expanding the imaginary factors into series, their product affords

$$\frac{2}{\sqrt[3]{(1 - \frac{3}{4} ee)}} \int (\alpha' + 2\beta' \cos. 2(M + \sigma) + 2\gamma' \cos. 4(M + \sigma) + \ldots) d\sigma;$$

where

$$\alpha' = \frac{1}{2}\sqrt[3]{(1 - \varepsilon')^2}\ \{1 + \left(\frac{1}{3}\right)^2 \varepsilon' + \left(\frac{1.4}{3.6}\right)^2 \varepsilon'^4 + \ldots\};$$

$$\beta' = \sqrt[3]{(1 - \varepsilon')}\left\{\frac{1}{3}\varepsilon' + \frac{1.4}{3.6} . \frac{1}{3}\varepsilon'^3 + \frac{1.4.7}{3.6.9} . \frac{1.4}{3.6}\varepsilon'^5 + \ldots\right\}; \text{ and}$$

$$\gamma' = \frac{1}{2}\sqrt[3]{(1-\varepsilon')^2}\left\{\frac{1.4}{3.6}\varepsilon' + \frac{1.4.7}{3.6.9}\cdot\frac{1}{3}\varepsilon'^4 + \frac{1.4.7.10}{3.6.9.12}\cdot\frac{1.4}{3.6}\varepsilon'^7 \ldots\right\}$$

Hence the fluent, reckoned from $\sigma = 0$, gives us

$$(12) \ldots w = \omega \frac{ee \sin. m}{\sqrt[3]{(1-\frac{3}{4}ee)}} \{\alpha'\sigma + \beta' \cos. (2M+\sigma) \sin. \sigma$$

$$+ \gamma' \cos. (4M+2\sigma) \sin. 2\sigma + \ldots\}$$

11.

The first two co-efficients of this series are contained in the 4th and 5th columns of the table; its argument is log. $\dfrac{e\sqrt{\frac{3}{4}}}{\sqrt{(1-\frac{3}{4}ee)}}$ cos. m. The approximation is of the same degree with that of the three former columns of the table. We compute ω according to a formula appropriate to the spherical triangle mentioned in § 3; either

$$\sin. \omega = \frac{\sin. \sigma \sin. \alpha'}{\cos. u} = \frac{-\sin. \sigma \sin. \alpha}{\cos. u'} = \frac{\sin. \sigma \sin. m}{\cos. u \cos. u'}; \text{ or}$$

$$\text{tang.} \frac{1}{2}\omega = \frac{\sin. \frac{1}{2}(u'-u)}{\cos. \frac{1}{2}(u'+u)} \text{tang.} \frac{1}{2}(\alpha'+\alpha) = \frac{\cos. \frac{1}{2}(u'-u)}{\sin. \frac{1}{2}(u'+u)}$$

tang. $\frac{1}{2}(\alpha'+\alpha)$, and we find the reduction to w by the help of the table.

In this manner I shall continue the computation of the example given in § 8, and shall proceed to find the difference of longitude between Dunkirk and Seeberg.

Log. sin. σ	=	8.96348383
$-$ sin. α	=	9.99969539 n
cos. u' A. C.	=	0.19967373
sin. ω	=	9.16285295; $\omega = -8° 21' 57''.741$.

The argument of the two last columns of the table is

$$\log. \frac{e\sqrt{\frac{3}{4}}}{\sqrt{(1-\frac{3}{4}ee)}} \cos. m$$

$$\log. \frac{e\sqrt{\frac{3}{4}}}{\sqrt{(1-\frac{3}{4}ee)}} = 8.844022$$

$$\cos. m = 9.890371$$

$$\text{Argument } 8.734393$$

$$\log. \alpha' = 9.698757 \qquad \log. \beta' = 1.703$$

$$-\sin. m = 9.799073 \qquad -\sin. m = 9.799$$

$$\frac{ee}{\sqrt[3]{(1-\frac{3}{4}ee)}} = 7.811575 \qquad \frac{ee}{\sqrt[3]{(1-\frac{3}{4}ee)}} = 7.812$$

$$\sigma = 4.278523 \qquad \cos. 2(M+\sigma) \sin. \sigma = 8.963\ n$$

$$1.587928 \qquad 8.277$$

$$+\ 38''.719 \qquad -\ 0''.019$$

so that the sum of both terms is $+\ 38''.700$, and the difference of longitude required is $w = -\ 8^\circ\ 21'\ 19''.041$.

12.

The explanation, which I have given of these tables, shows, that their employment does not imply the neglect of the higher powers of the eccentricity, but that they give the result as truly as the number of the decimal places allows. The computation, which affords this result, is in great measure the same as must be performed when we consider the earth as a sphere, and we have only added to this calculation, on account of the ellipticity of the earth, the solution of the equation (11) and the computation of the series (12). This computation is convenient enough, even for frequent repetition, and it appears therefore to be unnecessary to introduce any approximations which depend on the supposition of a measurement of small extent.

Table of Coefficients for Computation of the Geodetic Curve.

Arg.	Log. α	Diff.	Log. β	Diff.	Log. γ	Diff.	Log. α'	Diff.	Log. β'	Diff.
6.400	5.314 42513	1	7.5124	2000			9.698970	0	7.035	200
6.500	5.314 42512	0	7.7124	2000			9.698970	0	7.235	200
6.600	5.314 42512	1	7.9124	2000			9.698970	0	7.435	200
6.700	5.314 42511	2	8.1124	2000			9.698970	0	7.635	200
6.800	5.314 42509	3	8.3124	2000			9.698970	0	7.835	200
6.900	5.314 42506	4	8.5124	2000			9.698970	0	8.035	200
7.000	5.314 42502	6	8.7124	2000			9.698970	0	8.235	200
7.100	5.314 42496	10	8.9124	2000			9.698970	0	8.435	200
7.200	5.314 42486	16	9.1124	2000			9.698970	0	8.635	200
7.300	5.314 42470	25	9.3124	2000			9.698970	0	8.835	200
7.400	5.314 42445	40	9.5124	2000			9.698970	1	9.035	200
7.500	5.314 42405	5	9.7124	200			9.698969	0	9.235	20
7.510	5.314 42400	6	9.7324	200			9.698969	0	9.255	20
7.520	5.314 42394	5	9.7524	200			9.698969	0	9.275	20
7.530	5.314 42389	6	9.7724	200			9.698969	0	9.295	20
7.540	5.314 42383	6	9.7924	200			9.698969	0	9.315	20
7.550	5.314 42377	7	9.8124	200			9.698969	0	9.335	20
7.560	5.314 42370	7	9.8324	200			9.698969	0	9.355	20
7.570	5.314 42363	7	9.8524	200			9.698969	0	9.375	20
7.580	5.314 42356	7	9.8724	200			9.698969	0	9.395	20
7.590	5.314 42349	8	9.8924	200			9.698969	0	9.415	20
7.600	5.314 42341	8	9.9124	200			9.698969	0	9.435	20
7.610	5.314 42333	8	9.9324	200			9.698969	0	9.455	20
7.620	5.314 42325	9	9.9524	200			9.698969	0	9.475	20
7.630	5.314 42316	10	9.9724	200			9.698969	0	9 495	20
7.640	5.314 42306	9	9.9924	200			9.698969	0	9.515	20
7.650	5.314 42297	11	0.0124	200			9.698969	1	9.535	20
7.660	5.314 42286	10	0.0324	200			9.698968	0	9.555	20
7.670	5.314 42276	11	0.0524	200			9.698968	0	9.575	20
7.680	5.314 42265	12	0.0724	200			9.698968	0	9.595	20
7.690	5.314 42253	12	0.0924	200			9.698968	0	9.615	20
7.700	5.314 42241	13	0.1124	200			9.698968	0	9.635	20
7.710	5.314 42228	14	0.1324	200			9.698968	0	9.655	20
7.720	5.314 42214	14	0.1524	200			9.698968	0	9.675	20
7.730	5.314 42200	15	0.1724	200			9.698968	0	9.695	20
7.740	5.314 42185	15	0.1924	200			9.698968	0	9.715	20
7.750	5.314 42170	16	0.2124	200			9.698968	0	9.735	20
7.760	5.314 42154	17	0.2324	200			9.698968	1	9.755	20
7.770	5.314 42137	18	0.2524	200			9.698967	0	9.775	20
7.780	5.314 42119	18	0.2724	200			9.698967	0	9.795	20
7.790	5.314 42101	20	0.2924	200			9.698967	0	9.815	20
7.800	5.314 42081	20	0.3124	200			9.698967	0	9.835	20
7.810	5.314 42061	22	0.3334	200			9.698967	0	9.855	20
7.820	5.314 42039	22	0.3524	200			9.698967	0	9.875	20
7.830	5.314 42017	23	0.3724	200			9.698967	0	9.895	20
7.840	5.314 41994	25	0.3924	200			9.698967	1	9.915	28
7.850	5.314 41969	25	0.4124	200			9.698966	0	9.935	20
7.860	5.314 41944	27	0.4324	200			9.698966	0	9.955	20
7.870	5.314 41917	28	0.4524	200			9.698966	0	9.975	30
7.880	5.314 41889	30	0.4724	200			9.698966	0	9.995	20
7.890	5.314 41859	31	0.4924	200			9.698966	1	0.015	20
7.900	5.314 41828		0.5124				9.698965		0.035	

Arg.	Log. α	Diff	Log. β	Diff.	Log. γ	Diff.	Log. α'	Diff.	Log. β'	Diff.
7.900	5.314 41828	32	0.51235	2000			9.698965	0	0.035	20
7.910	5.314 41796	34	0.53235	2000			9.698965	0	0.055	20
7.920	5.314 41762	35	0.55235	2000			9.698965	0	0.075	20
7.930	5.314 41727	37	0.57235	2000			9.698965	0	0.095	20
7.940	5.314 41690	39	0.59235	2000			9.698965	1	0.115	20
7.950	5.314 41651	41	0.61235	2000			9.698964	0	0.135	20
7.960	5.314 41610	42	0.63235	2000			9.698964	0	0.155	20
7.970	5.314 41568	45	0.65235	2000			9.698964	1	0.175	20
7.980	5.314 41523	47	0.67235	1999			9.698963	0	0.195	20
7.990	5.314 41476	48	0.69234	2000			9.698963	0	0.215	20
8.000	5.314 41428	52	0.71234	2000			9.698963	1	0.235	20
8.010	5.314 41376	53	0.73234	2000			9.698962	0	0.255	20
8.020	5.314 41323	56	0.75234	2000			9.698962	0	0.275	20
8.030	5.314 41267	59	0.77234	2000			9.698962	1	0.295	20
8.040	5.314 41208	61	0.79234	2000			9.698961	0	0.315	20
8.050	5.314 41147	65	0.81234	2000			9.698961	1	0.335	20
8.060	5.314 41082	67	0.83234	2000			9.698960	0	0.355	20
8.070	5.314 41015	71	0.85234	1999			9.698960	0	0.375	20
8.080	5.314 40944	74	0.87233	2000			9.698960	1	0.395	20
8.090	5.314 40870	77	0.89233	2000			9.698959	0	0.415	20
8.100	5.314 40793	81	0.91233	2000			9.698959	1	0.435	20
8.110	5.314 40712	85	0.93233	2000			9.698958	1	0.455	20
8.120	5.314 40627	89	0.95233	2000			9.698957	0	0.475	20
8.130	5.314 40538	93	0.97233	1999			9.698957	1	0.495	20
8.140	5.314 40445	98	0.99232	2000			9.598956	0	0.515	20
8.150	5.314 40347	102	1.01232	2000			9.698956	1	0.535	20
8.160	5.314 40245	107	1.03232	2000			9.698955	1	0.555	20
8.170	5.314 40138	112	1.05232	2000			9.698954	1	0.575	20
8.180	5.314 40026	117	1.07232	1999			9.698953	0	0.595	20
8.190	5.314 39909	123	1.09231	2000			9.698953	1	0.615	20
8.200	5.314 39786	128	1.11231	2000			9.698952	1	0.635	20
8.210	5.314 39658	135	1.13231	2000			9.698951	1	0.655	20
8.220	5.314 39523	141	1.15231	1999			9.698950	1	0.675	20
8.230	5.314 39382	147	1.17230	2000			9.698949	1	0.695	20
8.240	5.314 39235	155	1.19230	2000			9.698948	1	0.715	20
8.250	5.314 39080	162	1.21230	1999	6.207	40	9.698947	1	0.735	20
8.260	5.314 38918	169	1.23229	2000	6.247	40	9.698946	1	0.755	20
8.270	5.314 38749	177	1.25229	2000	6.287	40	9.698945	1	0.775	20
8.280	5.314 38572	186	1.27229	1999	6.327	40	9.698944	2	0.795	20
8.290	5.314 38386	195	1.29228	2000	6.367	40	9.698942	1	0.815	20
8.300	5.314 38191	203	1.31228	1999	6.407	40	9.698941	1	0.835	20
8.310	5.314 37988	213	1.33227	2000	6.447	40	9.698940	2	0.855	20
8.320	5.314 37775	224	1.35227	2000	6.487	40	9.698938	1	0.875	20
8.330	5.314 37551	234	1.37227	1999	6.527	40	9.698937	2	0.895	20
8.340	5.314 37317	244	1.39226	2000	6.567	40	9.698935	1	0.915	20
8.350	5.314 37073	257	1.41226	1999	6.607	40	9.698934	2	0.935	20
8.360	5.314 36816	268	1.43225	2000	6.647	40	9.698932	2	0.955	20
8.370	5.314 36548	281	1.45225	1999	6.687	40	9.698930	2	0.975	20
8.380	5.314 36267	295	1.47224	1999	6.727	40	9.698928	2	0.995	20
8.390	5.314 35972	308	1.49223	2000	6.767	40	9.698926	2	1.015	20
8.400	5.314 35664		1.51223		6.807		9.698924		1.035	

Arg.	Log. α	Diff.	Log. β	Diff.	Log. γ	Diff.	Log. α'	Diff.	Log. β'	Diff.
8.400	5.314 35664	323	1.51223	1999	6.807	40	9.698924	2	1.035	20
8.410	5.314 35341	338	1.53222	1999	6.847	40	9.698922	2	1.055	20
8.420	5.314 35003	353	1.55221	2000	6.884	40	9.698920	2	1.075	20
8.430	5.314 34650	371	1.57221	1999	6.927	40	9.698918	3	1.095	20
8.440	5.314 34279	388	1.59220	1999	6.967	40	9.698915	2	1.115	20
8.450	5.314 33891	406	1.61219	1999	7.007	40	9.698913	3	1.135	20
8.460	5.314 33485	425	1.63218	2000	7.047	40	9.698910	3	1.155	20
8.470	5.314 33060	446	1.65218	1999	7.087	40	9.698907	3	1.175	20
8.480	5.314 32614	466	1.67217	1999	7.127	40	9.698904	3	1.195	20
8.490	5.314 32148	489	1.69216	1999	7.167	40	9.698901	3	1.215	20
8.500	5.314 31659	511	1.71215	1999	7.207	40	9.698898	4	1.235	20
8.510	5.314 31148	535	1.73214	1999	7.247	40	9.698894	3	1.255	20
8.520	5.314 30613	561	1.75213	1999	7.287	40	9.698891	4	1.275	20
8.530	5.314 30052	587	1.77212	1998	7.327	40	9.698887	4	1.295	20
8.540	5.314 29465	615	1.79210	1999	7.367	40	9.698883	4	1.315	20
8.550	5.314 28850	644	1.81209	1999	7.407	40	9.698879	4	1.335	20
8.560	5.314 28206	674	1.83208	1999	7.447	40	9.698875	5	1.355	20
8.570	5.314 27532	705	1.85207	1998	7.487	40	9.698870	5	1.375	20
8.580	5.314 26827	739	1.87205	1999	7.527	40	9.698865	5	1.395	20
8.590	5.314 26088	774	1.89204	1998	7.567	40	9 698860	5	1.415	20
8.600	5.314 25314	810	1.91202	1999	7.607	40	9.698855	5	1.435	20
8.610	5.314 24504	848	1.93201	1998	7.647	39	9.698850	6	1.455	20
8.620	5.314 23656	889	1.95199	1998	7.686	40	9.698844	6	1.475	20
8.630	5.314 22767	930	1.97197	1998	7.726	40	9.698838	6	1.495	20
8.640	5.314 21837	973	1.99195	1998	7.766	40	9.698832	6	1.515	20
8.650	5.314 20864	1020	2.01193	1998	7.806	40	9.698826	7	1.535	20
8.660	5.314 19844	1068	2.03191	1998	7.846	40	9.698819	7	1.555	20
8.670	5.314 18776	1118	2.05189	1998	7.886	40	9.698812	8	1.575	20
8.680	5.314 17658	1170	2.07187	1998	7.926	40	9.698804	7	1.595	20
8.690	5.314 16488	1226	2.09185	1997	7.966	40	9.698797	9	1.615	20
8.700	5.314 15262	1283	2.11182	1998	8.006	40	9.698788	8	1.635	19
8.710	5.314 13979	1344	2.13180	1997	8.046	40	9.698780	9	1.654	20
8.720	5.314 12635	1406	2.15177	1997	8.086	40	9.698771	10	1.674	20
8.730	5.314 11229	1473	2.17174	1997	8.126	40	9.698761	9	1.694	20
8.740	5.314 09756	1543	2.19171	1997	8.166	40	9.698752	11	1.714	20
8.750	5.314 08213	1615	2.21168	1997	8.206	40	9.698741	10	1.734	20
8.760	5.314 06598	1690	2.23165	1996	8.246	40	9.698731	12	1.754	20
8.770	5.314 04908	1771	2.25161	1997	8.286	40	9.698719	11	1.774	20
8.780	5.314 03137	1853	2.27158	1996	8.326	40	9.698708	13	1.794	20
8.790	5.314 01284	1941	2.29154	1996	8.366	40	9.698695	13	1.814	20
8.800	5.313 99343	1004	2.31150	998	8.406	19	9.698682	6	1.834	10
8.805	5.313 98339	1028	2.32148	998	8.425	20	9.698676	7	1.844	10
8.810	5.313 97311	1051	2.33146	998	8.445	20	9.698669	7	1.854	10
8.815	5.313 96260	1076	2.34144	998	8.465	20	9.698662	7	1.864	10
8.820	5.313 95184	1101	2.35142	998	8.485	20	9.698655	8	1.874	10
8.825	5.313 94083	1127	2.36140	998	8.505	20	9.698647	7	1.884	10
8.830	5.313 92956	1152	2.37138	997	8.525	20	9.698640	8	1.894	10
8.835	5.313 91804	1180	2.38135	998	8.545	20	9.698632	8	1.904	10
8.840	5.313 90624	1207	2.39133	998	8.565	20	9.698624	8	1.914	10
8.845	5.313 89417	1234	2.40131	997	8.585	20	9.698616	8	1.924	10
8.850	5.313 88183		2.41128		8.605		9.698608		1.934	

Arg.	Log. α	Diff.	Log. β	Diff.	Log. γ	Diff.	Log. α'	Diff	Log. β'	Diff.
8.850	5.313 88183	1264	2.411280	9975	8.605	20	9.698608	9	1.934	10
8.855	5.313 86919	1293	2.421255	9974	8.625	20	9.698599	8	1.944	10
8.860	5.313 85626	1323	2.431229	9974	8.645	20	9.698591	9	1.954	10
8.865	5.313 84303	1353	2.441203	9973	8.665	20	9.698582	9	1.964	10
8.870	5.313 82950	1385	2.451176	9962	8.685	20	9.698573	9	1.974	10
8.875	5.313 81565	1417	2.461148	9972	8.705	20	9.698564	10	1.984	10
8.880	5.313 80148	1450	2.471120	9971	8.725	20	9.698554	9	1.994	10
8.885	5.313 78698	1484	2.481091	9971	8.745	20	9.698545	10	2.004	10
8.890	5.313 77214	1518	2.491062	9969	8.765	20	9.698535	10	2.014	9
8.895	5.313 75696	1553	2.501031	9970	8.785	19	9.698525	11	2.023	10
8.900	5.313 74143	1590	2.511001	9968	8.804	20	9.698514	10	2.033	10
8.905	5.313 72553	1626	2.520969	9968	8.824	20	9.698504	11	2.043	10
8.910	5.313 70927	1664	2.530937	9966	8.844	20	9.698493	11	2.053	10
8.915	5.313 69263	1702	2.540903	9966	8.864	20	9.698482	12	2.063	10
8.920	5.313 67561	1742	2.550869	9965	8.884	20	9.698470	11	2.073	10
8.925	5.313 65819	1783	2.560834	9965	8.904	20	9.698459	12	2.083	10
8.930	5.313 64036	1824	2.570799	9964	8.924	20	9.699447	12	2.093	10
8.935	5.313 62212	1866	2.580763	9963	8.944	20	9.698435	13	2.103	10
8.940	5.313 60346	1909	2.590726	9962	8.964	20	9.698422	12	2.113	10
8.945	5.313 58437	1953	2.600688	9961	8.984	20	6.998410	13	2.123	10
8.950	5.313 56484	1999	2.610649	9960	9.004	20	9.698397	14	2.133	10
8.955	5.313 54485	2045	2.620609	9960	9.024	20	9.698383	13	2.143	10
8.960	5.313 52440	2093	2.630569	9958	9.044	20	9.698370	14	2.153	10
8.965	5.313 50347	2141	2.640527	9957	9.064	19	9.698356	14	2.163	10
8.970	5.313 48206	2191	2.650484	9957	9.083	20	9.698342	15	2.173	10
8.975	5.313 46015	2241	2.660441	9955	9.103	20	9.698327	15	2.183	10
8.980	5.313 43774	2293	2.670396	9955	9.123	20	9.968312	15	2.193	10
8.985	5.313 41481	2347	2.680351	9953	9.143	20	9.689297	16	2.203	9
8.990	5.313 39134	2400	2.690304	9952	9.163	20	9.698281	16	2.212	10
8.995	5.313 36734	2457	2.700256	9952	9.183	20	9.698265	16	2.222	10
9.000	5.313 34277	2513	2.710208	9950	9.203	20	9.698249	17	2.232	10
9.005	5.313 31764	2571	2.720158	9949	9.223	20	9.698232	17	2.242	10
9.010	5.313 29193	2631	2.730107	9944	9.243	20	9.698215	18	2.252	10
9.015	5.313 26562	2691	2.740054	9947	9.263	20	9.698197	18	2.262	10
9.020	5.313 23871	2754	2.750001	9954	9.283	19	9.698179	18	2.272	10
9.025	5.313 21117	2818	2.759946	9944	9.302	20	9.698161	19	2.282	10
9.030	5.313 18299	2883	2.769890	9943	9.322	20	9.698142	19	2.292	10
9.035	5.313 15416	2949	2.779833	9941	9.342	20	9.698123	20	2.302	10
9.040	5.313 12467	3018	2.789774	9941	9.362	20	9.698103	20	2.312	10
9.045	5.313 09449	3087	2.799715	9939	9.382	20	9.698083	20	2.322	10
9.050	5.313 06362	3159	2.809654	9937	9.402	20	9.698063	21	2.332	10
9.055	5.313 03203	3232	2.819591	9936	9.422	19	9.698042	22	2.342	9
9.060	5.312 99971	3306	2.829527	9934	9.441	20	9.698020	22	2.351	10
9.065	5.312 96665	3383	2.839461	9933	9.461	20	9.697998	22	2.361	10
9.070	5.312 93282	3460	2.849394	9931	9.481	20	9.697976	23	2.371	10
9.075	5.312 89822	3541	2.859325	9930	9.501	20	9.697953	24	2.381	10
9.080	5.312 86281	3623	2.869255	9929	9.521	20	9.697929	24	2.391	10
9.085	5.312 82658	3706	2.879184	9926	9.541	20	9.597905	25	2.401	10
9.090	5.312 78952	3791	2.889110	9925	9.561	20	9.697880	25	2.411	10
9.095	5.312 75161	3879	2.899035	9923	9.581	19	9.697855	26	2.421	10
9.100	5.312 71282		2.909058		9.600		9.697829		2.431	

iii. *A simple* Rectification *of the* Geodetic Curve. *By the* Editor.

Professor Bessel's investigation of the properties of the geodetic curve, though most ingenious and successful, is yet so intricate and complicated, that it is easier to obtain a new solution of the problem, than to verify the steps of his researches in such a manner, as to fulfil the whole duty of a scientific translator.—For obtaining this solution, it is only necessary to set out in a right direction; and considering the dependence of the curve on the distance from the axis, r, it is natural to inquire whether its properties may not be most conveniently expressed in terms of that quantity. The equation of the ellipsis being $\frac{xx}{aa} + \frac{yy}{bb} = 1$, and x being the r of this investigation, we have $\frac{rr}{aa} + \frac{yy}{bb} = 1$, $\frac{r\mathrm{d}r}{aa} + \frac{y\mathrm{d}y}{bb} = 0$; and the square of the fluxion of the arc of the meridian, which is equal to $\mathrm{d}r^2 + \mathrm{d}y^2$, $\mathrm{d}y$ being $= -\frac{bb}{aa}\frac{r}{y}\mathrm{d}r$, becomes $\mathrm{d}r^2 + \frac{b^4}{a^4}\frac{rr}{yy}\mathrm{d}r^2$, or since $y^2 = b^2 - \frac{bb}{aa}r^2$, $\mathrm{d}r^2\left(1 + \frac{b^4}{a^4} - \frac{a^2r^2}{a^2b^2 - b^2r^2}\right) = \mathrm{d}r^2\left(1 + \frac{b^2r^2}{a^4 - a^2r^2}\right)$; and making the least value of r equal to g, we have every where $\frac{g}{r}$ for the sine of the azimuth, and for the square of its cosine $1 - \frac{gg}{rr} = \frac{rr - gg}{rr}$. Hence $\mathrm{d}s^2 = \mathrm{d}r^2\frac{rr}{rr - gg}\left(1 + \frac{b^2r^2}{a^4 - a^2r^2}\right)$. Making now $r^2 - g^2 = \gamma^2$, we have $r\mathrm{d}r = \gamma\mathrm{d}\gamma$, $\mathrm{d}r = \frac{\gamma\mathrm{d}\gamma}{r}$, $\mathrm{d}r^2 = \frac{\gamma\gamma}{rr}\mathrm{d}\gamma^2$, and $\mathrm{d}s^2 = \mathrm{d}\gamma^2\left(1 + \frac{b^2r^2}{a^4 - a^2r^2}\right) = \mathrm{d}\gamma^2\frac{a^4 - (a^2 - b^2)r^2}{a^4 - a^2r^2}$; or, if $a^2 - b^2 = c^2$, $\mathrm{d}\gamma^2 = \frac{a^4 - e^2r^2}{a^4 - a^2r^2}$, and $\mathrm{d}s = \mathrm{d}\gamma\sqrt{(a^4 - e^2g^2 - e^2\gamma^2)}\sqrt{\frac{1}{a^4 - a^2g^2 - a^2\gamma^2}}$

$= d\gamma\sqrt{(a^4 - e^2g^2)}\ \sqrt{(1 - \frac{e^2}{a^4 - e^2g^2}\gamma^2)}\ \sqrt{\frac{1}{a^4 - a^2g^2}}$

$\sqrt{\frac{1}{1 - \frac{\gamma\gamma}{aa - gg}}} = d\gamma\sqrt{(a^4 - e^2g^2)}\ \sqrt{(1 - f^2\chi^2)}\ \sqrt{\frac{1}{a^4 - a^2g^2}}$

$\sqrt{\frac{1}{1 - \chi\chi}}$; χ^2 being $= \frac{\gamma\gamma}{aa - gg}$, $f^2\chi^2 = \frac{e^2}{a^4 - e^2g^2}\gamma^2$, or

$f^2 = \frac{aa - gg}{a^4 - e^2g^2}e^2$; so that $d\chi = \frac{d\gamma}{\sqrt{(aa - gg)}}$; whence $ds =$

$d\chi\sqrt{(aa - gg)}\ \sqrt{\frac{a^4 - e^2g^2}{a^4 - a^2g^2}}\ \sqrt{(1 - f^2\chi^2)}\ \sqrt{\frac{1}{1 - \chi\chi}} = \sqrt{(a^2 - \frac{ee}{aa}g^2)}\ \frac{d\chi}{\sqrt{(1 - \chi\chi)}}\ (1 - \frac{1}{2}f^2\chi^2 + \frac{1}{8}f^4\chi^4 - \frac{1}{16}f^6\chi^6 + \frac{5}{128}f^8\chi^8 - \ldots)$. The fluents may be found by Hirsch's Tables, p. 143; and we shall have $s = \sqrt{(a^2 - \frac{ee}{aa}g^2)}\ (P - \frac{1}{2}f^2Q + \frac{1}{8}f^4R - \frac{1}{16}f^6S + \ldots)$; P being arc sin χ, $Q = \frac{P - \chi\cos.P}{2}$,

$R = \frac{3Q - \chi^3\cos.P}{4}$, $S = \frac{5R - \chi^5\cos.P}{6}$, $T = \frac{7S - \chi^7\cos.P}{8}$,

and so forth.

It will be convenient to have the values of these fluents expressed in a table, for different values of χ, or $\sqrt{\frac{rr - gg}{aa - gg}}$, from 0 to 1; such a table will probably be inserted in the next number of these Collections; and it may also be useful on many other occasions, giving, for example, the length of an elliptical arc, when $g = 0$, $\chi = \frac{r}{a}$, f being then $= \frac{e}{a}$.

The value of r may be readily found from the latitude and the ellipticity: for t being the tangent of the latitude, we have $t = \frac{dr}{dy} = \frac{aa}{bb}\frac{y}{r}$; $t^2 = \frac{a^4}{b^4}.\frac{yy}{rr}$, $y^2 = b^2 - \frac{bb}{aa}r^2$; $t^2 = \frac{a^4}{b^4}$.

$\frac{a^2b^2 - b^2r^2}{a^2r^2} = \frac{aa}{bb} \cdot \frac{aa - rr}{rr}$; $\frac{bb}{aa} r^2t^2 = a^2 - r^2$; $\left(\frac{bb}{aa} t^2 + 1\right)$ $r^2 = a^2$, and $r^2 = \frac{a^4}{bbtt + aa} = \frac{a^2}{\frac{bb}{aa} t^2 + 1}$; and if we made $a = 1$, and $b = 1 - \varepsilon$, $r^2 = \frac{1}{1 + tt - 2\varepsilon tt + \varepsilon\varepsilon tt}$; or, if $\varepsilon = \frac{1}{300}$, $r^2 = \frac{1}{1 + \frac{149}{150} tt}$, very nearly.

Having found the values of r, for any two latitudes, by this formula, we can easily compute the corresponding value of s; and if s is given by measurement, we can correct the supposed value r from the error of s, and the azimuth of the curve, the sine of which is always $\frac{g}{r}$.

In order to find the angular difference of longitude, we must multiply the fluxion ds by the sine $\frac{g}{r}$, and divide it by the radius r, and we have $\frac{g\mathrm{d}s}{rr} = \frac{g}{rr} \sqrt{\frac{rr}{rr - gg}} \sqrt{\frac{ar - e^2r^2}{a^4 - a^2r^2}}\, \mathrm{d}r =$ $\frac{g\mathrm{d}r}{r} \sqrt{\frac{a^4 - e^2r^2}{(a^4 + a^2g^2)r^2 - a^2r^4 - a^4g^2}} = \frac{g\mathrm{d}(r^2)}{2rr}$, $\sqrt{\frac{a^4 - e^2r^2}{(a^4 + a^2g^2)r^2 - a^2r^4 - a^4g^2}}$; of which the fluent may be found by comparison with the $\int \frac{x^m \mathrm{d}x}{\sqrt{(a + bx + cx^2)}}$ of Hirsch, p. 187, 183, 185; Suppl. Enc. Brit. Art. Fluents, No. 353; or perhaps more conveniently by multiplying the series already found into the developement of $\frac{1}{rr} = \frac{1}{gg + \gamma\gamma} = \frac{1}{gg} \cdot \frac{1}{1 + \frac{\gamma\gamma}{gg}} = \frac{1}{gg}$ $\left(1 - \frac{\gamma\gamma}{gg} + \frac{\gamma^4}{g^4} - \frac{\gamma^6}{g^6} + \ldots\right)$; and this will be sufficiently convergent when γ is small: when larger, the direct computation of the fluents will be required, which is necessarily a little more tedious, as it cannot be materially assisted by a table; and this may possibly have been the reason that Professor Bessel has employed a different mode of investigation.

IV. *Two Rules for finding the* LATITUDE *at Sea, by one* ALTITUDE, *and the Interval between* TWO *Observations of the* AZIMUTH. By CHARLES BLACKBURN, Esq., A B.

As the deviation of the compass from the different positions of a ship's head has been corrected by the invention of Professor Barlow, the following rules are proposed as convenient methods of finding the latitude at sea, when the latitude is less than the declination and of the same name with it.

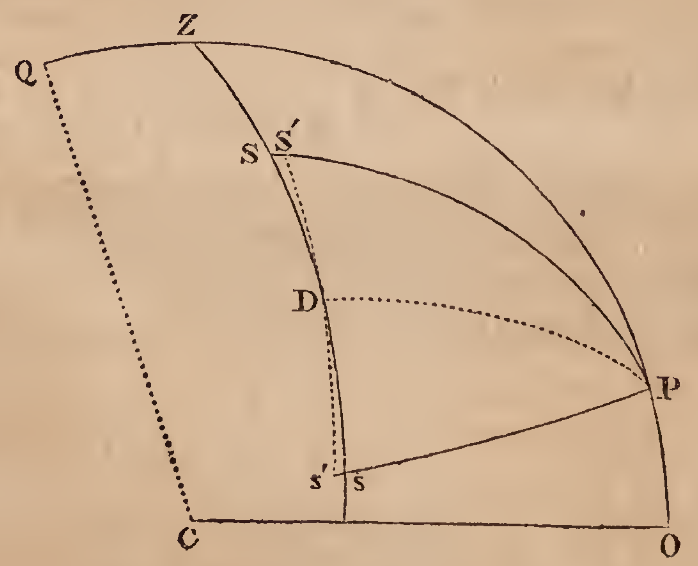
Let the letters D, P, Z represent respectively the declination, polar and zenith distances at the greater altitude; p the polar distance at the less altitude; P' the mean polar distance, and T the elapsed time; then,

RULE I.

Add together the log. sin. P', the log. sin. $\frac{1}{2}T$, and reject 10 from the index; look for the remainder among the log. sines; twice the corresponding arc will be arc I.

Let $P+I$ be called S; then add together the log. cosecant I, the log. sin. Z, the log. sin. $\frac{1}{2}\overline{S+p}$, the log. sin. $\frac{1}{2}\overline{S-p}$, the logarithm of 2, and reject 30 from the index.

Subtract the natural number belonging to the remainder, from the nat. sin. $\overline{Z+D}$; the remainder will be the nat. sin. of the true latitude.



DEMONSTRATION.

Let the figure represent a projection of the E. or W. hemisphere upon the plane of the meridian. Z the zenith; P the pole; CO the horizon; S, s two places of the sun on the same vertical Zs;

PS, Ps meridians; let PD, an arc of a great circle, bisect the angle SPs, and intersect Ss in D; through D draw $S's'$ at right angles to PD; then PS' will be the mean declination; and $S'S$ the half change of declination in the interval, nearly.

In the triangle $S'PD$, we have

$$\text{Rad.} \times \sin S'D = \sin. PS' \times \sin. S'PD$$

or $\sin. S'D = \dfrac{\sin. P \times \sin. \frac{1}{2} T}{\text{rad.}}$ which is the first part of the rule. Again,

* $\cos. ZP = \cos. (PS \backsim ZS) - \dfrac{2. \sin. ZS \times \sin. \frac{1}{2}(PS + Ss + Ps) \times \sin. \frac{1}{2}(PS + Ss - Ps)}{r^3 \times \sin. Ss}$

or $\sin. \text{lat.} = \sin. (Z + D) - \dfrac{\sin. Z \times \sin. \frac{1}{2}\overline{S+p} \times \sin. \frac{1}{2}\overline{S-p}.2}{\text{rad.}^3 \times \sin. I.}$

which is the second part of the rule.

Example.

June 9th, 1825, P.M., an observation was made of the sun's azimuth; his true altitude at that time being 83°, and his polar distance 67° 0′ 35″. After an interval of 5^h 48^m, he was observed to have the same azimuth. Required the latitude.

To find arc I.

l. sin. P' =	9.964026
l. sin. $\frac{1}{2} T$ =	9.837812
39° 19′ 7″	9.801838 = l. s.
2	
I = 78 38 14	

To find lat.

l. cosec. I =	0.008597
l. sin. Z =	9.085894
l. sin. $\frac{1}{2}\overline{S+p}$ =	9.982142
l. sin. $\frac{1}{2}\overline{S-p}$	9.801927
constant log.	0.301030
N = 151214 . . .	9.179590
n. sin. $\overline{Z+D}$	499853
$-N$ =	151214
Lat. 20° 24′ 15″	348639

	°	′	″
I =	78	38	14
P =	67	0	35
	145	38	49
p =	66	59	25
	212	38	14
	78	39	24
$\frac{1}{2}\overline{S+p}$ =	106	19	7
$\frac{1}{2}\overline{S-p}$ =	39	19	42
D =	22	59	25
Z =	7		
$Z+D$ =	29	59	25

* See Vol. XVIII. page 99.

No error is introduced into the operation by making use of the mean polar distance, in the first part of the rule. For in the triangle *SPD*, *PD* and the angle *SPD* are constant; hence $\dot{SD} = -\dot{PS} \times \frac{\cos. PSD}{\text{rad.}}$; and in like manner, $\dot{sD} = \dot{Ps} \times \frac{\cos. PsD}{\text{rad.}}$, and therefore $\dot{Ss} = \dot{Ps} \times \frac{\cos. PsD}{\text{rad.}} - \dot{PS} \times \frac{\cos. PSD}{\text{rad.}}, = \frac{1}{2}.\overline{D-d} \times (\cos. PsD - \cos. PSD) \times \frac{1}{\text{rad.}}$, a quantity which may be neglected. Hence *S's'* may be substituted for *Ss* in the operation without sensible error, and the rule, as above stated, will, if the observations be correctly taken, in all cases, give the latitude within a second of the truth. But as the observations are seldom free from error, it becomes necessary to inquire what effect any small errors of observation will have upon the latitude.

First, to find the error in the latitude arising from an error in the observation of the altitude.

In the triangle *ZSP*, we have *ZSP*, and *PS* constant, hence $\dot{ZP} = \dot{ZS} \times \frac{\cos. PZS}{\text{rad.}}$. Let *M* represent the azimuth, then $\dot{L} = \dot{A} \times \frac{\cos. M}{\text{rad.}}$.

Suppose, for instance, that in the last example the altitude had been erroneously taken as 83° 1′ instead of 83°, then

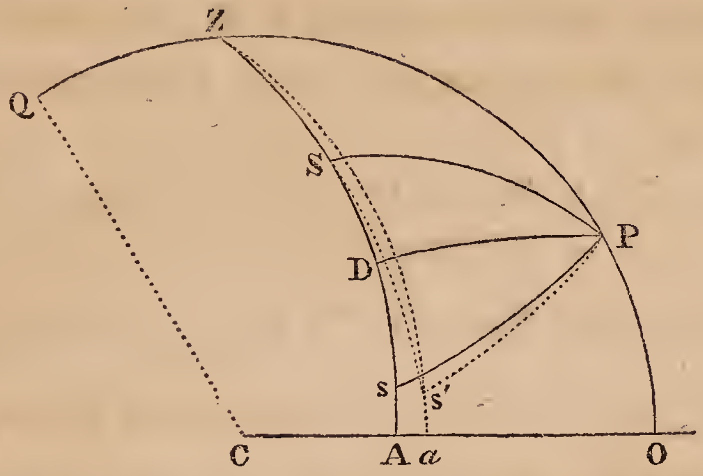
log. cosec. $I =$	0.008597
l. sin. $Z =$	9.084864
l. sin. $\frac{1}{2}\overline{S+p} =$	9.982142
l. sin. $\frac{1}{2}\overline{S-p} =$	9.801927
log. 2	0.301030
$N = 150855$.	9.178560
n. sin. $\overline{Z+D} =$	499601
$-N =$	150855
lat. = 20° 24′ 38″	348746
true lat. = 20 24 15	
	23″ = error.

Computation of the error to find *M*.

l. tan. $\overline{Z+\frac{1}{2}l} =$		10.0199
l. tan. $L =$		9.5704
$M = 67°\ 5'$		9.5903 = l. cos.
log. 60″ . .		1.7781
computed error	23″.6	1.3684

agreeing with the actual error.

Secondly, to find the error in the latitude from an error in the observation of the azimuth.



Let Aa, fig. 2, be the error of observation; draw the vertical Za; then the sun's place, instead of s, will be in reality s'. In the triangle ZSs', we have sin. ZSs' : sin. SZs' : : sin. Zs' : sin. Ss', or $P\dot{S}s : \dot{M}$: : sin. Zs : sin. Ss, and $\therefore$ $P\dot{S}s = \dot{M} \times \dfrac{\text{sin. } Zs}{\text{sin. } Ss}$. Again in the triangle ZSP, ZS and PS are constant, hence $Z\dot{P} = Z\dot{S}P \times \dfrac{\text{sin. } PZS}{\text{cosec. } ZS}$, and therefore by substitution $\dot{L} = \dot{M} \times \dfrac{\text{sin. } Zs \times \text{sin. } PZS}{\text{sin. } Ss \times \text{cosec. } ZS}$ or $\dot{L} = \dot{M} \times$ cosec. $I \times$ sin. $M \times$ sin. $Z \times$ sin. $\overline{Z+I}$.

To compute the error on supposition of an error of 15′ in the determination of the azimuths.

log. cosec. I	=	0.0086
l. sin. Z	=	9.0859
l. sin. M	=	9.9643
l. sin. $\overline{Z+I}$	=	9.9987
log. 15′	=	1.1761
Error 1′.712		0.2336

If then an error of a quarter of a degree be supposed in the determination of *each* azimuth, and of 3 minutes in the altitude, and all three errors to combine to produce an erroneous result; the latitude as determined by the rule will not differ more than 4′ 36″ from the truth; not much more than $\frac{1}{3}$d of the error to which the result would have been liable, had the example been worked by the common method of two altitudes on the same side of the meridian.

EXAMPLE II.

March 10, 1825, in the forenoon, an observation was made of the sun's azimuth; after an interval of 4^h 16^m, when on the same vertical, his true altitude was 74° 20′. Required the latitude.

To find arc I.

log. sin. P'	=	9.998941
l. sin. $\frac{1}{2}T$	=	9.724210
31° 54′ 46″		9.723151
2		
I = 63 49 32		

	°	′	″
I =	63	49	32
P =	86	2	5
	149	51	37
p =	85	57	55
	235	49	32
	63	53	42
$\frac{1}{2}\overline{S+p}$ =	117	54	46
$\frac{1}{2}\overline{S-p}$ =	31	56	51

To find the lat.

l. cosec. I	=	0.046987
l. sin. Z	=	9.431429
l. sin. $\frac{1}{2}\overline{S+p}$		9.946286
l. sin. $\frac{1}{2}\overline{S-p}$		9.723572
const. log.	=	0.301030
N = 281388		9.449304
n. sin. $\overline{Z+D}$	=	335977
	= N =	281388
lat. = 3° 7′ 41″		054589

To compute the error in lat. arising from an error of 3′ in alt.

l. cos. M	=	8.7751
log. 3′	=	0.4771
error = .1787		$\bar{1}$.2522

To compute the error in latitude from an error of 15′ in each azimuth.

l. cosec. I	=	0.0470
l. sin. Z	=	9.4314
l. sin. M	=	9.9992
l. sin. $\overline{Z+I}$		9.9926
30′	=	1.4771
8′.857	. .	0.9473

error from az.	=	8.857
error from alt.	=	0.179
		9.036
total er.		9′ 2″

The error in this latter example, though considerable, is not one-tenth of that to which the result would have been liable by the method of double altitudes.

It appears from the formulæ, that in general the greater the difference between the altitudes at the two observations, the less will the latitude be affected by any errors either of azimuth or altitude.

Rule II.

Add together the log. sin. P, the log. sin. $\frac{1}{2}T$, and reject 10 from the index, the remainder will be the log. sin. of arc θ.

Add together the log. secant θ, the log. cos. $\overline{Z+\theta}$, the log. cos. P, and reject 20 from the index, the remainder will be the log. sin. of the latitude.

Demonstration.

In the triangle SPD (fig. 1), if D be considered as a right angle, we have, rad. $\times$ sin. SD = sin. SP $\times$ sin. SPD

$$\text{or sin. } \theta = \text{sin. } P \times \text{sin. } \tfrac{1}{2} T \times \frac{1}{R},$$ which is the first part of the rule.

Again, $R \times \text{cos. } ZP = \text{cos. } ZD \times \text{cos. } PD$; but

$$\text{cos. } PD = \frac{R \times \text{cos. } PS}{\text{cos. } SD},$$ therefore by substitution we have

$$\text{cos. } ZP \times \frac{\text{cos. } ZD \times \text{cos. } PS}{\text{cos. } SD}$$

$$\text{or sin. lat} = \text{sec. } \theta \times \text{cos. } \overline{Z+\theta} \times \text{cos. } P \times \frac{1}{R^2},$$

which is the second part of the rule.

To compute the first example by this rule.

To find θ.		To find the lat.	
l. sin. P =	9.964057	l. sec. θ =	0.111485
l. sin. $\frac{1}{2}T$ =	9.837812	l. cos. $\overline{Z+\theta}$ =	9.839230
θ = 39° 19′ 19″	9.801869	l. cos. P =	9.591704
		Lat. = 20° 24′ 22″	9.542419

The true latitude is 20° 24′ 15″, differing by 7″ from the latitude found by the latter method. The error (which arises from the angle SDP having in the computation been supposed a right angle, and from the change of declination in the interval not having been allowed for) will always be in *excess* if the polar distance at the greater altitude be *greater* than the other polar distance, and always in *defect* when the polar distance at the greater altitude is *less* than the other polar distance.

To find a general expression for this error.

In the triangle SPD, if SPD and PD be supposed constant, we have $\dot{SD}$ or $\dot{ZD} = \dot{PS} \times \frac{\cos. PSD}{\text{rad.}}$; and in the same triangle $\dot{PDS}$ or $\dot{PDZ} = \dot{PS} \times \frac{\sin. PSD}{\sin. SD}$.

Again in the triangle PDZ, if ZD and PD be supposed constant, we have $\dot{ZP} = \dot{PDZ} \times \frac{\sin. PZD}{\text{cosec.} ZD}$, and $\therefore$ by substitution we have $\dot{ZP} = \dot{PS} \times \frac{\sin. PSD \times \sin. PZD}{\sin. SD \times \text{cosec.} ZD} = \dot{L}$ arising from the variation of the angle ZDP.

Again, in the triangle ZDP, if PD and PDZ be considered constant, we have $\dot{ZP} = \dot{ZD} \times \frac{\cos. PZD}{\text{rad.}}$; but $\dot{ZD}$ was shown to be $= \dot{PS} \times \frac{\cos. PSD}{\text{rad.}}$; hence by substitution $\dot{ZP} = \dot{PS} \times \frac{\cos. PSD \times \cos. PZD}{\text{rad.}^2}$, always of a different affection from the former expression.

Again in the right-angled triangle PSD, we have SPD constant; hence $\dot{PD} = \dot{PS} \times \frac{\sin. PSD}{\cos. SD}$.

And in the triangle PDZ, if ZD and ZDP be supposed constant, we have $\dot{ZP} = \dot{PD} \times \frac{\cos. ZPD}{\text{rad.}}$ or $\dot{ZP} = \dot{PD} \times \frac{\sin. PZD \times \cos. ZD}{\text{rad.}^2}$; but $\dot{PD} = \dot{PS} \times \frac{\sin. PSD}{\cos. SD}$ and $\therefore \dot{ZP} = \dot{PS} \times \frac{\sin. PSD \times \sin. PZD \times \cos. ZD}{\cos. SD \times R^2}$, likewise of a different affection from the first expression.

Hence, collecting the terms, we have

$$\dot{ZP} = \dot{PS} \times \left\{ \frac{\sin. PSD \times \sin. PZD}{\sin. SD \times \text{cosec.} ZD} - \frac{\sin. PSD \times \sin. PZD \times \cos. ZD}{\cos. SD \times R^2} - \frac{\cos. PSD \times \cos. PZD}{R^2} \right\}$$

which expression by substitution and reduction becomes

$$\dot{ZP} = \dot{PS} \times \left\{ \frac{\text{sin. } PSD \times \text{sin. } PZD \times \text{sin. } ZS \times 2}{R^2 \times \text{sin. } Ss} - \frac{\text{cos. } PSD \times \text{cos. } PZD}{R^2} \right\}$$

To compute the error of the last example by this formula,

l. sin. PSD = 9.9720			l. cos. PSD = 9.5411
l. sin. PZD = 9.9643			l. cos. PZD = 9.5903
l. sin. ZS = 9.0859			log. 35″ = 1.5441
l. cosec. Ss = 0.0086		− 4.737	8.6755
log. $P'S$ = 35″ = 1.5441		+ 7.515	
log. 2 = 0.3010		2.″778 = the computed error.	
7.515 . . . 0.8759			

The real error is 7 seconds, as was shown above; the difference therefore between the actual and computed error, is in this case about 4″. In general the greater the difference between the altitudes at the two observations, the less will the latitude by this rule differ from the true one. As the difference approaches to 90°, the error vanishes, and the latter method becomes as correct as the former. The formulæ for the errors in latitude arising from those of altitude or azimuth will be the same for this rule as for the first, which may be thus shown.

In the triangle ZSP, PS, and ZSP are constant by the supposition; hence $\dot{ZP} = \dot{ZS} \times \frac{\text{cos. } PZS}{\text{rad.}}$, or $\dot{L} = \dot{A} \times \frac{\text{cos. } M}{\text{rad.}}$ as before.

Secondly, to find $\dot{L}$ in terms of $\dot{Az}$. In the triangle

ZSs' (fig. 2), sin. ZSs' : sin. SZs :: sin. Zs' : sin. Ss' ∴

or $\dot{PSs} : \dot{M}$ :: sin. Zs : sin. Ss and $\dot{PSs} = \dot{M} \times \frac{\text{sin. } Zs}{\text{sin. } Ss}$.

In the right-angled triangle SPD, PS is constant, hence

$$\dot{SD} \text{ or } \dot{ZD} = \text{cos. } SD \times \text{tan. } PD \times \dot{PSD}$$

and by substitution $\dot{ZD} = \dot{M} \times \frac{\text{sin. } Zs \times \text{cos. } SD \times \text{tan. } PD}{\text{sin. } Ss}$

Again in the same triangle $\dot{PD} = \dot{PSD} \times \text{sin. } SD$.

$$\text{or } \dot{PD} = \frac{\text{sin. } Zs \times \text{sin. } SD}{\text{sin. } Ss}.$$

M 2

In the triangle *ZPD*, if *PD* be supposed constant, we have $\dot{ZP} = \dot{ZD} \times$ cos. *PZD*, or by substitution,

$$\dot{ZP} = \dot{M} \times \frac{\text{sin. } Zs \times \text{cos. } SD \times \text{tan. } PD \times \text{cos. } PZD}{\text{sin. } Ss}$$

$$\text{or } \dot{ZP} = \dot{M} \times \frac{\text{sin. } Zs \times \text{cos. } SD \times \text{sin. } ZD \times \text{sin. } PZD}{\text{sin. } Ss}.$$

Again, in the same triangle, if *ZD* be supposed constant, we have $\dot{ZP} = \dot{PD} \times$ cos. $ZPD = \dot{PD} \times$ sin. $PZD \times$ cos. *ZD*, by substitution $\dot{ZP} = \dot{M} \times \dfrac{\text{sin. } Zs \times \text{sin. } SD \times \text{sin. } PZD \times \text{cos. } ZD}{\text{sin. } Ss}$

whence collecting the terms, the whole expression for *ZP* will be

$$\dot{M} \times \left\{\frac{\text{sin.}Zs \times \text{cos.}SD \times \text{sin.}ZD \times \text{sin.}PZD - \text{sin.}Zs \times \text{sin.}SD \times \text{sin.}PZD \times \text{cos.}ZD}{\text{sin. } Ss}\right\},$$

$$\dot{ZP} = \dot{M} \times \frac{(\text{cos.}SD \times \text{sin.}ZD - \text{sin.}SD \times \text{cos.}ZD) \times \text{sin.}Zs \times \text{sin.}PZD}{\text{sin. } Ss}$$

$$\dot{ZP} = \dot{M} \times \frac{\text{sin. } ZS \times \text{sin. } Zs \times \text{sin. } PZD}{\text{sin. } Ss}$$

or $\dot{L} = \dot{M} \times$ sin. $Z \times$ sin. $\overline{Z + I} \times$ sin. $M \times$ cosec. *M* as before.

EXAMPLE II.

To find θ.	To find the Lat.
l. sin. $P = 9.998959$	l. sec. $\theta = 0.071175$
l. sin. $\frac{1}{2}T = 9.724210$	l. cos. $\overline{Z+\theta} = 9.829011$
$\theta = 31°\ 54'\ 52''$ $9.723169 =$ l. *s*.	l. cos. $P = 8.839804$
$Z = 15\ \ 40$	Lat. $= 3°\ 9'\ 1'' - 8.739990 =$ l. *s*.
$Z+\theta = 47\ \ 34\ \ 42$	

The true latitude is 3° 7′ 41″, the error therefore, in this case, amounts to 1′ 20″ in defect.

To compute the error from the formula,

l. sin. $PSD = 9.9996$	l. cos. $PSD = 8.6390$
l. sin. $PZD = 9.9992$	l. cos. $PZD = 8.7751$
l. sin. $ZS = 9.4314$	l. $125'' - 2.0969$
l. cosec. $Ss = 0.0470$	0.32 $\quad \bar{1}.5110$
l. $125'' = 2.0969$	75.01
l $\quad 2\ \ 0.3010$	$74.''69 =$ computed error
$75''.01 - 1.8750$	differing about 5″ from the real one.

It may here be observed, that the formulæ for the errors, with the computations of them, are not to be considered as forming any part of the operation for finding the latitude, but as introduced merely to enable the seaman to judge how far the rules may be depended upon in practice. The Table which accompanies this paper exhibits the time from noon, when the sun attains his greatest azimuth, for every degree of declination and latitude within the limits of the rule, and may serve as a guide with respect to the times of making the observations.

The advantages of these methods are,

1. They are not half the length of the common operation of finding the latitude by observations off the meridian.

2. They have no distinction of cases.

3. They require no correction, for change of place in the interval.

4. They are applicable at a time when the method of double altitudes becomes objectionable from the errors to which it is liable.

5. One of the observations may be made, if convenient, even when the sun is in the horizon.

6. The azimuths do not require correcting for the variation.

TABLE *of the time of* GREATEST AZIMUTH.

DECLINATION.	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Lat. 3°	2 46	3 33	4 0	4 19	4 32	4 43	4 51	4 57	5 3	5 7
4		2 26	3 13	3 41	4 1	4 15	4 26	4 36	4 43	4 49
5			2 15	2 58	3 26	3 46	4 1	4 12	4 23	4 30
6				2 4	2 47	3 14	3 34	3 49	4 1	4 12
7					1 56	2 37	3 3	3 23	3 39	3 51
8						1 50	2 29	2 55	3 14	3 29
9							1 44	2 22	2 47	3 7
10								1 40	2 16	2 41
11									1 35	2 11
12										1 32

DECLINATION.	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Lat. 3°	5 11	5 15	5 18	5 20	5 23	5 25	5 27	5 29	5 30	5 31
4	4 55	4 59	5 3	5 7	5 10	5 13	5 15	5 18	5 20	5 22
5	4 38	4 44	4 49	4 53	4 57	5 1	5 4	5 7	5 10	5 12
6	4 20	4 28	4 34	4 40	4 44	4 49	4 53	4 56	4 59	5 3
7	4 2	4 10	4 19	4 25	4 31	4 36	4 41	4 45	4 49	4 52
8	3 43	3 53	4 3	4 10	4 17	4 24	4 29	4 34	4 39	4 43
9	3 22	3 35	3 46	3 56	4 3	4 10	4 17	4 23	4 27	4 32
10	3 0	3 15	3 28	3 39	3 48	3 57	4 4	4 11	4 16	4 22
11	2 33	2 54	3 9	3 22	3 33	3 42	3 51	3 58	4 5	4 11
12	2 6	2 30	2 49	3 4	3 17	3 27	3 37	3 45	3 53	4 0
13	1 29	2 2	2 26	2 44	2 59	3 12	3 22	3 32	3 41	3 48
14		1 26	1 58	2 21	2 39	2 54	3 7	3 18	3 28	3 36
15			1 24	1 55	2 18	3 36	2 50	3 3	3 14	3 23
16				1 21	1 52	2 22	2 32	2 47	2 59	3 10
17					1 18	1 50	2 11	2 29	2 43	2 56
18						1 17	1 47	2 9	2 26	2 40
19							1 16	1 45	2 6	2 23
20								1 14	1 43	2 4
21									1 13	1 41

v. *Considerations on the Reduction of the* LENGTH *of the* PENDULUM *to the* LEVEL *of the* SEA. *By the* EDITOR.

MR. LAPLACE seems to entertain some doubts of the propriety of considering the density of an elevated portion of the earth's surface, in reducing the length of the pendulum, observed on it, to the level of the sea. The respect, due to the opinions of so illustrious a mathematician, renders it therefore necessary to enter into some further explanations on this subject.

If the earth be considered as a sphere, either of uniform density, or disposed in concentric strata, except at a small part near the end of one of its radii, where we may suppose a spherule to be situated of a density so much greater as to exceed that of the neighbouring parts by the mean density, and touching the surface internally; the distance of its centre from that of the earth being a; then at the angular distance φ from the given radius, and at the distance z from the centre of the spherule, the direct attraction will be $\frac{n^3}{zz}$, n being $= 1 - a$, or the radius of the spherule, and the angular deflection of the pendulum, or of the surface of the sea, or of that of an atmosphere, the disturbing force $\frac{n}{zz}$, being reduced in the ratio of the sine of the angle subtended by the side a, will be $\frac{n^3}{zz} . \frac{a \sin. \varphi}{z} = \frac{an^3 \sin. \varphi}{z^3}$; and the fluxion of the elevation corresponding to $d\varphi$, the angle being very small, will be $\frac{an^3 \sin. \varphi}{z^3} d\varphi$. Now $z^2 = (\cos. \varphi - a)^2 + \sin.^2\varphi = \cos.^2\varphi + a^2 - 2a \cos. \varphi + \sin.^2\varphi = 1 + a^2 - 2a \cos. \varphi$; and the fluxion of $\frac{1}{\sqrt{(1 + a^2 - 2a \cos. \varphi)}}$ is $- \frac{a \sin. \varphi d\varphi}{z^3}$; consequently the fluent of $\frac{an^3 \sin. \varphi}{z^3} d\varphi$ is $\frac{n^3}{z}$. Making, for example, $a = .999$, as for a spherule about 8 miles in diameter, and $n = .001$, the fluent at the remotest extremity is $\frac{.000000001}{1.999}$; and taking the distance $z = 1$ as giving about the mean level of the sea, the correction will be $\left(\frac{.001}{1}\right)^3$ and the elevation, over the spherule, $(.001)^2 - (.001)^3$, or nearly one millionth of the radius; that is, about 21 feet. Such would therefore

be the elevation of the true level of the sea by the attraction of the supposed spherule; and whether we reduced the length of a pendulum to this level, or to the surface of the sphere, the difference would be insensible: while the real force of gravity, and consequently the length of the pendulum, would be increased one-thousandth by the presence of such a spherule, and the curvature of the meridian at the spot would be deranged in a still greater degree.

If the sphere were now contracted to the radius a, and the surface were covered with an atmosphere of the height of the diameter of the spherule, it is obvious that the spherule remaining in its place would become a mountain of the mean density of the earth, and the surface of the atmosphere would still be in equilibrium at the height of 21 feet only above the original surface of the sphere: and the spherule might be flattened into a table land, without any sensible alteration of its action, provided that the place of its centre of gravity remained but little changed. In any case the length of the pendulum at the surface of the globular mountain, or of the table land, would be manifestly affected by the attraction of the prominence, and consequently by its density, while the actual elevation or depression of the level of the sea would comparatively be very inconsiderable: this elevation may therefore safely be neglected in practical cases; while it is impossible to compare the length of the pendulum in different latitudes, as referred to any regular spheroid, in a satisfactory manner, without first making corrections for the effect of such accidental irregularities, as far as it is in our power to ascertain them.

It must however be observed, that the correction, taken in this general sense, cannot be considered as coming under the denomination of a reduction to the *local* level of the sea. In the case of the sphere, for example, diminished to $1-2n$, the length of the pendulum at the general level of the sea would be $1+4n$, at the summit of the globular mountain $1+n$ only; immediately below it, $1+4n-n=1-3n$, while, if we allowed for the height only, without considering the attraction of the mountain, it would be supposed $1+n+4n=1+5n$, as much exceeding the required value, belonging to the general level of the sea, and independent of the local attraction, as the result of the actual experiment under the mountain would fall short of it.

T. Y.

9, *Park Square, Portland Place,*
16 *March,* 1826.

Art. XIV. MISCELLANEOUS INTELLIGENCE.

I. Mechanical Science.

1. *Blasting of Rocks.*—The method of blasting, invented by Jessop, is exclusively practised in the quarries of Soleure, and admits of some applications, as in the lifting of blocks out of their places after being blasted, of great service. This method consists in simply covering the powder with sand. The first explosion frequently detaches a large block from the rock, separating it, however, only by an interval of a few lines, or an inch. The subdivision and dressing of such a mass, in a similar situation, presents difficulties and requires time. To obviate this it is, however, sufficient to introduce a second charge of powder into the same hole and into the same cleft, and to cover the whole with sand throughout the extent of the aperture. The explosion of the second charge finds sufficient resistance to push the block horizontally to a distance of 1, 2, 3, or 4 feet from its bed, without breaking or at all damaging it. The removal or working of the stone then becomes much facilitated.

As an instance—a hole was made in the rock, 3½ inches in diameter, and 14½ feet deep. The first charge of 18 pounds of powder, filled it to a height of 8 feet, the remaining 6½ feet were filled with dry coarse sand. The explosion produced a dull sound, and separated the block from the rock by an interval of 2 or 3 lines. The second charge of powder was 15 lbs.; it filled the hole to a height of 2 feet, and 4 measures of sand were required to fill the hole and the cleft which had been formed. The second explosion also produced a dull sound, the block was pushed 4 feet from its original place without any injury. This block was 14½ feet high. 16 feet wide, and 21 feet long: it contained, therefore, 5,568 cubical feet: and as the cubic foot of this stone weighs 130 pounds, its total weight was 723,840 lbs. In its rough state its value was estimated at 800 Swiss francs, or about 1200 French francs.

A variation in the nature of the charge has been introduced by M. Varnhagen, of Brazil. The following is an instance of its application:—the hole was 3½ inches in diameter, and 13 feet deep; a mixture was made of 5 lbs. of powder, and twice its volume of deal-wood saw-dust, slightly moist, and sufficiently fine to pass a sieve, having holes 2 lines in diameter. This mixture was pressed lightly into the hole, and filled it to a height of 7½ feet; after placing a match the remaining 5½ feet were filled with sand. According to the report of the workmen, the explosion produced as complete and satisfactory an effect as would

have been produced by 12 lbs. of powder applied in the usual manner. The block detached was 26 feet long, 13 feet high, and 11 feet wide; it contained 3718 cubic feet, and was separated from the surface of the rock by an interval of 9 inches.

M. Pfluger, who details these experiments, states, that the men are so satisfied with Jessop's simple mode, that they cannot be persuaded to adopt Varnhagen's improvement in the saving of powder; and yet some years ago, they required the utmost inducement to adopt Jessop's plan. It was only by promising to replace all the powder that might be expended in useless efforts, that they could be induced to try it.—*Bib. Univ.* xxx. 231.

2. *Indian Method of twisting Iron for Gun-barrels, &c.* By Captain Bagnold.—The gun-barrels made at Bombay in imitation of those of Damascus, so much valued by the Orientals for the beauty of their twist, are manufactured from iron hoops obtained from European casks, mostly British. The more these hoops are corroded by rust, they are proportionably acceptable to the workmen; should there be any deficiency of this necessary oxidation, they are regularly exposed to moisture until they are sufficiently prepared for welding. Being cut into lengths of about 12 inches, they are formed into a pile an inch or an inch and a half high, laying the edges straight so as not to overlap each other: a larger piece is then so fitted as to return over each end, and hold the whole together in the fire. This pile is then heated, and drawn out into a bar of about one inch wide and one-third of an inch thick; it is doubled up in three or more lengths, and again drawn out as before; and this operation is repeated generally to the third or fourth time, according to the degree of fineness required. The bar is then to be heated about one-third of its length at a time, and, being struck on the edge, is flattened out the contrary way to that of the stratification. This part of the operation brings the wire or vein outwards upon the strap. The barrel is then forged in the usual way, but much more jumping is used than in the English method, in order to render the twist finer. The most careful workmen always make a practice of covering the part exposed to the fire with a lute composed of mud, clay, and the dung of cows or horses, in order to guard against any unnecessary oxidation of the metal. When the barrel is complete, the twist is raised by laying the barrel from one to five days either in vinegar or a solution of the sulphate of iron, until the twist is raised; this process is called the wire-twist. To produce the curl, the bars or straps are drawn out into bars about three-quarters of an inch square, and twisted some to the right and others to the left, one of each sort is then welded together, doubled up, and drawn out as before; and upon the experience of the workman, any intricacy of twist is produced by this drawing out, doubling, and twisting.

Sometimes, to save trouble and economize iron thus prepared, the artist will rough-file an English barrel, weld a strap of Damascus iron spirally round it, or several are laid longitudinally, and welded on. A native artist never works with coal under any consideration. Charcoal from light woods forms his only fuel.

In making the sword-blades, there are several methods used; some make a pile of alternate layers of soft and hardened steel, with powdered cast iron mixed with borax sprinkled between each layer. These are drawn out to one-third more than the length of the intended blade, doubled up, heated, twisted, and re-forged several times; the twist is brought up in the same way as that in the gun-barrels.

Some swords are forged out of two *broad* plates of steel thus prepared, with a narrow plate of good iron welded between them, leaving a solid steel for the edge of considerable depth. Others prefer making them of one plate of steel, with a lamina of iron on each side of it to give strength and toughness.

Swords of this description were tempered in my brother's presence in the following compound, and as he states with considerable effect: the blade was covered with a paste formed of equal parts of barilla, powdered egg-shells, borax, salt, and crude soda, heated to a moderate red heat; and just as the red is changing to a black heat, quench it in spring-water.

From the information of this workman, it appears Damascus obtains all its steel from the upper part of Deccan, where it is called the *fonlode hind*, or Indian steel, of which there are great quantities, but little or no demand for it. The damasque, or *joar*, is natural to this steel, and is raised by immersing it in an acid solution.—*Trans. Soc. Arts*, xliii. 106.

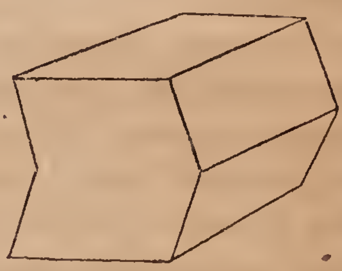
3. *Iron Bridge of Suspension at St. Petersburg.*—It is in contemplation to build an iron suspension bridge across the Neva at St. Petersburg—a project suggested in consequence of the difficulty or impossibility of erecting one of wood or stone. The bottom of the river is about 42 feet beneath the ordinary level of the waters, and inundations increase this by 18 or 20 feet. The proposed bridge is to have an arch of 1022 feet span. It is to be composed of three distinct bridges: one on each side, 9 feet wide, for carts, &c.; a middle one, with a road 21 feet wide, for carriages, and two pathways, of 5 feet each, for foot passengers. The suspension-chains are to have a total section of 400 square inches.—*Ann. des Mines*, xi. 265.

4. *Minimum of Adhesion in Steel, &c.*—It is a fact perhaps not generally known to those who have written on the subject, that at the heat called black heat, but which is in fact nearly or quite a red heat in the dark, steel is broken or separated by fracture

with much less force than when heated *more or less*, the requisite temperature varying probably in proportion to the carbon contained in the steel. The disposition to be easily separated by fracture, at a particular heat, exists in carbonized or cast-iron, in the alloys of copper and of tin, is very perceptible in flint-glass, and perhaps in all factitious metallic compounds, some requiring a moderate and others a more intense heat.—*Silliman's Journ.* x. 128.

5. *Expanding Wedge for Sawyers.*—This instrument, the invention of Mr. Griffiths, of the Royal Institution, consists of a handle or centre-piece, and two lateral or spring-pieces, all made of clear sound ash ; these are inserted at one end into a wedge-shaped brass or iron cap, so that the side pieces, by their divergence, form a continuation of its sides. On the handle is fixed an upright nearly in the centre of gravity, which being surmounted by a cross-bar, supports the instrument between the planks. The instrument is intended chiefly to save the time and trouble of shifting the common wedges while sawing up balks of fir into deals ; and being introduced into the first cut of two or three feet, will continue expanding and opening the plank for a length of 12 feet. It is sometimes made of iron and steel.—*Trans. Soc. Arts*, xliii. 88.

6. *New Pitched Pavement.*—A mode of pitching pavement is proposed, founded, as the inventor states, upon the reciprocal bearing and support of the stones. The pavement is formed of granite, or other hard paving-stones, of the ordinary size, and each stone is laid or ranged in such a manner, with reference to the several contiguous stones, as that neither can be displaced the eighth-part of an inch by any pressure or percussion, however great, in the ordinary use of streets. The stones are not wedges or cubes, but formed as in the margin ; each contains a protruding or salient angle on the one side, and an indented or receding angle on the opposite side, the receding angle being formed to receive the salient one. In a prospectus put forth, the mode of pitching such a pavement, and raising a stone when required, is depicted and described. The inventor states that its advantages will consist in its level symmetry and uniformity, its cleanliness, its strength and solidity, derived by each part from the whole superficies, facility when laying down and raising, and probable durability. The expense of thus cutting or dressing the stones is not mentioned. It is called the Biangular Pavement.



7. *Improved Melting-pots for Iron and Brass.*—Mr. L. Anstey, of Somers-town, has been rewarded by the Society of Arts for his improvement of melting-pots for iron and brass-founders; and, from the testimonials of those who have used them, they appear to merit great attention. They are composed of two parts Stourbridge-clay, and one part of the hardest coke, well-ground, and tempered together. The materials should be ground separately, and passed through a sieve of one-eighth of an inch mesh, then mixed with water and well-trodden. If the coke be ground too fine the pots are apt to crack. They are then moulded by hand on a block, over a cone previously covered with a cap of linen or cotton to facilitate their removal. They are then carefully dried at a gentle heat, the cap drawn out, and the pots are ready for use. The smaller pots hold 20 lbs. of cast iron, and cost 10*d.* each; the larger hold 40 lbs. and cost 14*d.*

When wanted for use the pot is first warmed, then put into the furnace with the mouth downwards upon fresh coke; more coke is then thrown in until the pot is covered, and it is gradually brought to a red heat; the pot is then turned in the furnace, fixed in its proper position, charged with cold iron, no flux or addition of any kind being used, and in about one hour and a half the metal is melted. Such a pot will last for 16 or 18 successive fusions, if it be not allowed to cool in the interval; if it cools it will probably crack. These pots bear a higher heat than others, and will deliver the metal in a more fluid state than the best Birmingham pots. Experimental trials fully supported the character of the pots, drawn from practical experience.—*Trans. Soc. Arts*, xliii. 33.

8. *On the Association of numerous Solar Spots, with increased mean Meteorological Temperatures.*—The Editor of the *Annales de Chimie*, after a numerous list of solar spots observed in 1825, observes, that distinguished astronomers and philosophers have advanced, however extraordinary it may appear, that the appearance of spots on the sun's disc is the indication of an abundant emission of light and heat. The thermometrical observations of the last year appear to confirm this opinion. The solar spots, as is seen in the table, are very numerous; and by reference to the meteorological tables, it is found that the mean temperature at Paris, of the same year, is raised more than one degree. It may be remarked, however, that in consequence of the multiplicity and great variety of causes which modify the terrestrial temperatures, isolated results will never conduct to certain general conclusions. It is only by grouping long series of observations that we can hope to appreciate the immediate influence of these spots. Tables, analogous to those which the Editor has given, containing the results of the year's observations, will, if rendered

complete, one day furnish the true elements of this curious research. This consideration should induce astronomers henceforth to indicate in their journals the form and dimensions of the spots which they may from day to day observe on the sun's disc; and though the cloudy state of our skies may interfere with the observations of an individual, yet the attention of many being called to this point, it is hoped that satisfactory results may be obtained.—*Ann. de Chimie*, xxx. 409.

II. Chemical Science.

1. *On the mutual Decomposition of Bodies. By* M. Gay-Lussac. —We owe to Berthollet the important law, that bodies of analogous properties displace each other mutually from their combinations, and that the principal causes which limit their separation are volatility and insolubility. Perhaps Berthollet has not sufficiently developed the consequences of this law, but it is easy to state them in each particular case.

When two acids act on a base, the whole resting in solution, the base is divided between them, not according to their ponderable quantity, but according to the number of their atoms; and it does not seem that its affinity for each acid has in general any great part in the phenomena. It is sufficient for the division of the base, that the acids, whatever their difference of volatility and solubility, remain in solution, for then they should act as if they enjoyed these two properties in the same degree.

Suppose, for instance, that excess of nitric acid is poured into solution of chloride of sodium, muriatic acid and chlorine will immediately appear in the mixture; and if heat be applied, the chloride soon becomes nitrate of soda. On inverting the experiment, *i. e.*, treating nitrate of soda by muriatic acid in excess, it will readily be converted into a chloride.

These reciprocal decompositions are very easy, and by converting two nitrates into chlorides, we may easily determine the proportions in which they are mixed; we merely have to know the weight of the two chlorides, and the two nitrates, and the atomic weights of each salt. All the chlorides are not decomposed with equal facility by nitric acid; the chloride of silver, which is completely insoluble in water and in acids, is not touched; and that of calcium is more refractory than those of potassium and sodium. But it must be observed, that we here compare compounds, as the chlorides and nitrates not analogous in their nature, and that the law under consideration cannot apply to them, except as we consider the chlorides as remaining in solution indifferently as muriates or chlorides; and this is not always the case.

Sulphuric acid, at common temperatures, partly separates bo-

racic and arsenic acids from their combinations; but at a high temperature it is expelled from combinations by those acids.

Nitric and muriatic acids decompose the fluorides, but nitrates and muriates are in turn decomposed by fluoric acid.

Acetic acid decomposes many chlorides, and reciprocally muriatic acid decomposes many acetates. Many other vetegable acids, and particularly the lactic, present the same phenomena.

Gases soluble in water and separable in vacuo, are all expelled from this liquid by another gas passed in excess.

Numerous other facts of a similar kind may be quoted, but we confine ourselves to the cases of decomposition of a hydro-sulphuret by carbonic acid, and of carbonates by sulphuretted hydrogen, on which M. Henry has experimented at length *, to demonstrate what the simple consideration of the laws of Berthollet would have shewn.

The bi-carbonate of potash, for example, exposed in solution to contact of air, loses a portion of its acid, and acquires the power of precipitating sulphate of magnesia. If a current of sulphuretted hydrogen gas, of which the acid properties, as is known, are nearly the same as those of carbonic acid, be passed through it, a portion of carbonic acid will necessarily be liberated; and, as it will be carried off by the current of sulphuretted hydrogen, the bi-carbonate will always remain in the same circumstances of decomposition, and by degrees the latter will be completed.

In the same way, by passing a current of carbonic acid gas through a hydro-sulphuret, the latter will be partially decomposed, the sulphuretted hydrogen set at liberty will be carried off by the carbonic acid current; the decomposition of the hydro-sulphuret will therefore be successive, and ultimately complete.

It must be remarked that these decompositions require a quantity of acid far greater than that necessary to saturate the base, for the acid eliminated can escape from the solution only by means of the excess of acid which replaces it, according to the theory of vapours.

It is to be observed also, that if the carbonate and hydro-sulphuret be not in the state of bi-salts, a disengagement of their acids does not commence until they have arrived at this state. M. Henry has observed, that the insoluble carbonates are decomposed, but in a very slight degree, by sulphuretted hydrogen, and this is easily comprehended; but that which is not so necessary a consequence is, that, according to the same experiments, the carbonates are decomposed with greater difficulty by sulphuretted hydrogen than the hydro-sulphurets are by carbonic acid.—*Ann. de Chim.* xxx. 291.

* *Quarterly Journal of Science,* xx. p. 393.

2. *Test of the presence of Organic Exhalations in the Atmosphere.*—Il Signor Bizio having noticed the powerful effect exerted by anhydrous sulphuric acid in vapour over organic exhalations in the air, and the consequent production of black carbonaceous spots, has proposed the use of it for this purpose, and has dignified a little glass instrument, in which a portion of air is exposed to the vapours of Nordhausen acid, by the name of the *diaftoroscopio.* He states, that he has experimented frequently with the air of his laboratory, but never found it free from these kinds of exhalations.

By putting different substances into the air operated upon; as, for instance, putrid matter, alcohol, essential oils, camphor, ether, odorous resins, &c., a saturated atmosphere was procured, and results, in some degree comparative, obtained. The vapour of alcohol gave the most carbonaceous indication, and after it camphor. Ether gave no indications above that of the air containing it.—*Giornale di Fisica*, viii. 403.

3. *Existence of Lithia in the Mineral Waters of Bohemia.*—M. Berzelius, in a letter to M. Dulong, states, that he has found lithia to be a constant and essential element in the mineral waters of Bohemia. To detect and separate the lithia, he pours a solution of phosphate of soda into the mineral water, evaporates to dryness, and re-dissolves in cold water. The lithia is left in the state of an insoluble phosphate of lithia and soda. Berzelius considers it also as probable, that lithia exists in sea-water, but M. Mulder has not been able to find it in the waters of the Zuider-Zee.—*Ann. Phil.* N. S. xi. 69.

4. *Action of Anhydrous Sulphuric Acid upon Metals.*—Il Signior Bizio has ascertained by experiment, that the vapour of anhydrous sulphuric acid has no action upon zinc, copper, iron, silver, lead, tin, brass, or mercury, even when passed over them for more than an hour together. If water be present, action takes place, and hence it is necessary perfectly to dry the air in the vessels, or else the experiments will fail.—*Giornale di Fisica*, viii. 407.

5. *On the State of Fecula in the fructifying Organs of Grain, &c.*—A long memoir on the developement of the fecula in grain, accompanied with the details of numerous experiments and microscopical observations, has been communicated to the Philomatic Society of Paris, by M. Raspael, who has arrived in it at some very novel conclusions. These we have selected, and we refer those, who may feel enough interest in the subject to desire further information, to the *Annales de Sciences Naturelles*, vi. 384, &c.

i. Fecula is not composed of crystallizations, but of vegetable organs in the form of globules.

ii. Fecula takes a violet or indigo colour from iodine, not in consequence of a new combination, but by simple coloration.

iii. Each grain of fecula is formed of—1, a smooth integument, unacted upon by water or acids at common temperatures, but susceptible of being coloured for a long time by iodine; and 2, of a soluble substance, which by evaporation loses its property of becoming coloured by iodine, and obtains all the qualities of gum.

iv. Consequently those gums which run from vegetables are simply this soluble substance of fecula, which, by exposure to air, has lost the property of becoming blue by iodine.

v. The property of becoming blue by iodine is due to a volatile body.

vi. Bodies of a yellow colour, like that of tincture of iodine, may exist in all vegetables, and capable, by superposition on the surface of the grains of fecula, of giving to this substance the property of transmitting blue light, more or less pure.

6. *On the Oil obtained during the Rectification of Alcohol from Potatoes.* By M. G. Pelletan.—MM. Bertillon and Guietand, manufacturers of rectified spirits, have obtained, amongst the last products of distillation by the naked fire, of the fermented fecula of potatoes, a peculiar oil, which they believed to resemble that produced by the rectification of corn spirit. M. Pelletan particularly examined this substance, and purified it by repeated washings with water, and rectification from pulverized chloride of calcium.

It is colourless, limpid, very fluid, has a penetrating odour, a hot, acrid, and persisting taste, and does not soil paper. Its specific gravity is 0.821 at 57° F. It is very fluid at 0° F., but two or three degrees lower it assumes the appearance of congealed oil of aniseed; it boils at 257° F. The impure oil boils much sooner, in consequence of the alcohol and water it contains, but as these bodies leave it, its boiling point approaches to 257°.

This substance burns with flame, it takes fire by the approach of a burning body, but is soon extinguished; it does not burn continuously unless it be previously heated. Water dissolves a sufficient quantity of it to have its specific gravity diminished by 0.0102; it then assumes the smell of the oil, and froths by agitation. The oil also dissolves water, and when saturated has its specific gravity increased 0.0229. It is soluble in all proportions in alcohol, and water does not separate it, unless it be in great quantity compared to the alcohol; and when but little water is added, the oil separated re-dissolves by agitation.

Fat, the fixed and volatile oils, camphor, resins, and iodine, are

soluble in this oil. Sulphur and caoutchouc dissolve in it in small quantities when heated, but are precipitated as the solution cools.

Concentrated sulphuric acid readily mixes with it, producing a crimson colour. Water destroys the mixture, and the oil swims, of a light yellow colour. When heated the oil is decomposed, and a liquid is obtained, saturated with sulphurous acid, and having a disagreeable alliaceous odour. On saturating the sulphurous acid with potash, and distilling, the liquid is less odorous, and has a specific gravity of 0.797; but on exposing it under the exhausted receiver of an air-pump, it is restored to 0.821. It may be judged from analogy with the mode of action of other acids, that a little ether had been formed.

The oil is insoluble in nitric acid; by heat nitric ether is obtained. It absorbs cold muriatic acid gas, and becomes black. The mixture agitated with water disengages a vapour, presenting the characters of muriatic ether. Chlorine renders it green, and at the end of some days yields a result similar to that obtained with muriatic acid. Concentrated acetic acid mixes with it in all proportions, and the acetate of potash dissolves in it very readily.

Potash, soda, and ammonia, dissolve in the oil in considerable quantity, but without saponifying it; the addition of water destroys the combination. Potassum decomposes it rapidly at the ordinary temperature. It separates the chloride of gold from water, and preserves it without alteration.

These facts tend to cause a suspicion that the oil still contains a certain quantity of alcohol, which has escaped the washings with water. If it should ultimately prove impossible further to concentrate it, we may regard this substance as intermediate between alcohol and the ordinary volatile oils, yet merely as a modification of alcohol, and preserving the property of forming ethers with acids.—*Ann. de Chimie*, xxx. 221.

7. *Corrected Views relative to Picrotoxia and Menispermic Acid.*—M. J. L. Casaseca has made a particular examination of the *Cocculus Indicus*, with a view of confirming the results obtained by M. Boullay. The latter chemist concluded from his first experiments on the berries, that they contained, amongst other things, malic acid, and a bitter venomous crystallizable substance; but since then he has concluded, that the acid is distinct in its properties from all others, and has been by him, therefore, called the *menispermic acid*, and the bitter principle he has considered as a new salifiable base, classing with the vegeto-alkalies, and has named it *picrotoxia*.

M. Casaseca, in his experiments, made expressly with a view to the integrity of these two substances, has come to very different

conclusions on the subject, and gives his reasons, which seem good ones, for so doing. His results generalized are, 1. That there is no such acid as the menispermic: 2. That the properties attributed to it, and which induced M. Boullay to consider it as a new vegetable acid, are due to a mixture of sulphuric acid with a particular organic matter: 3. That picrotoxia does not possess alkaline properties, and should not be considered as a new vegetable salifiable base, but as a particular bitter vegetable principle, as M. Boullay at first announced.—*Ann. de Chimie*, xxx. 307.

8. *Preservation of Lemon or Lime Juice.*—Lemon or lime juice, according to the experiments of Captain Bagnold, may be preserved without the addition of rum, spirit, or any other substance, by the process well known and practised for the preserving of green gooseberries and other fruits for domestic purposes. Lime juice was expressed from the fruit in Jamaica, in September, 1823, strained, put into quart bottles, and carefully corked; these being put into a pan of cold water, were gradually raised to the boiling point; they were retained at that point for half an hour, and then allowed to cool. A bottle opened in April, 1824, was found to contain the juice in the state of a whitish turbid liquor, with the acidity and much of the flavour of the lime, nor did it appear to have undergone any alteration. The same juice again bottled and heated was set aside till March, 1825, when, upon examination, it was found in good condition, retaining much of the flavour of the recent juice.—*Trans. Soc. Arts*, xliii. 52.

9. *Tanners' Extract of Mimosa Bark.*—Extract of Mimosa bark still continues to be prepared in New South Wales, and Messrs. Petchey and Wood were rewarded by the Society of Arts for making and importing five tons of it to this country. The extract was made by boiling the bark in water for twelve hours, straining the liquor, again boiling for twenty-four hours, again straining, boiling a third twenty-four hours, straining, cooling, and running the extracts into casks. It is of the consistency of tar or treacle; has no empyreumatic flavour; is entirely soluble in cold water, and is considered as equally powerful with extract of oak bark of similar consistence.—*Trans. Soc. Arts*, xliii. 206.

10. *On the Mutual Action of Salt Water and Soap*, by M. Colin.—I proved by experiments on soap, printed in 1816, in the *Annales de Chimie*, iii. that salt, in proper quantity, had the power of precipitating it, and rendering it hard and friable, and that soap thus precipitated required a fresh portion of alkali to dissolve it. Hence it was observed care must be taken not to harden it too much, least the water beneath it retained the alkali and caused loss. The insolubility of soap in these circumstances has just been remarked by M. Vauquelin, who, in a note to the Academy

of Medicine, has shown that a weak solution of salt is capable of producing an analogous effect, and in consequence endeavours to establish that it is not caused by the affinity of the water; I am inclined to the same opinion: in fact, the saline precipitates obtained by the mutual action of two salts are less soluble than the salts themselves.

Now, M. Chevreul, having shewn that soaps are salts, it may be readily understood that they may combine with common salt in such a way as to lose their solubility. M. Robiquet informs me, that pieces of soap placed in salt water gain in weight, whilst the solution becomes less saline; and as it is known that water frequently separates a salt into two portions, one acid and the other alkaline, an effect which happens with soap itself, and by means of which M. Chevreul separates the nacreous matter, it may easily be comprehended that the intervention of a third substance, feeble in itself, may modify this separation, and render it more distinct.

From these facts M. Vauquelin draws as a conclusion that sea-water can never serve for washing, and that it is an error to suppose certain English soaps are more proper for seamen's uses than those of France. He proposes to replace soap at sea by certain vegetable mucilages, as is practised in some parts on shore. It may be observed that the potato has been proposed for this purpose, and that the effect is good. This is easily verified. All alimentary matters have, indeed, the power of absorbing fat, as may be seen in the preparation of our food. It would be easy to substitute for potatoes, useless roots and fruits such as the horse-chestnut, &c., and a certain portion of sub-carbonate of potash, or soda, might be added to them.

I had occasion, some time since, to examine a small specimen of English soap, fit, as it was said, for the uses of seamen, but it acted with the chlorides of lime and soda exactly like those manufactured in France.—*Ann. de Chimie*, xxx. 321.

11. *Modification of Albumen.*—Certain observations made by M. Colin, relative to the appearances of albumen when acted upon by different agents, lead him to conclude that the substances, in some of their states, are analogous to that observed by M. Vauquelin in the waters of Vichy*, and also have some relation to the animal substance discovered by M. Longchamp in mineral water, and by him called *Barregine*.

In operating with acids upon albumen in experiments on fermentation, I found that it acquired a blue colour when digested with sugar, water, and camphoric acid, at a gentle heat, for a few moments; the heat was sufficient to coagulate a little of the

* *Quarterly Journal of Science*, xix. p. 359.

albumen. Blue, green, and red colours have also been obtained by treating albumen with dilute sulphuric acid, then concentrating the liquor till it gelatinized, afterwards throwing it upon a filter and washing it for a long time: after some days the filter became coloured blue in some places, and in others red and green. An aqueous solution of albumen precipitated by muriatic acid, and washed on a filter, became of a fine red colour. This may also be produced at pleasure by albumen and sulphuric acid, and M. Fremy has shewn me a red liquor obtained in this way.

These facts tend to establish the possibility of reproducing the animal matter found in the Vichy waters, for this body has also the property of becoming blue, and, according to M. Vauquelin, it otherwise agrees with albumen. They also appear to me equally to show the possibility of converting albuminous matter into the colouring matter of the blood. Certainly the red substance thus produced is insoluble, but it is known that treatment by acids also renders the red colouring matter of the blood insoluble. The study of these phenomena would, probably, prove very interesting.—*Ann. de Chimie*, xxx. 323.

12. *On Sulpho-naphthalic Acid*, &c.—Mr. Faraday has lately communicated a paper to the Royal Society, the object of which is to show that during the mutual action of sulphuric acid and naphthaline, a compound of the acid with hydro-carbon is formed, differing from all known substances, and which, possessing acid properties and combining with salifiable bases to produce a peculiar class of salts, has been distinguished as the sulpho-naphthalic acid.

The acid is formed whenever sulphuric acid and naphthaline are placed in contact, even at common temperatures, but it is more convenient to introduce about two parts of naphthaline and one part of concentrated sulphuric acid into a flask, to raise the temperature until the naphthaline melts, and to agitate; combination is effected without any material action as to the ultimate elements of the substance operated upon, and after repose and cooling in tubes, two substances are found, both in the solid state. The lighter is naphthaline, containing a little of the peculiar acid in union with it; it is crystalline and hard, like common naphthaline, but of a red colour; when melted and agitated with water, the acid is washed out, and the naphthaline separates.

The lower and heavier substance is also crystalline, but softer than the upper; it is red, of an acid bitter taste, absorbs moisture from the air, and consists principally of the hydrated peculiar acid, containing some uncombined naphthaline; it is distinguished as the *impure solid acid*. When rubbed in a mortar with water, by far the greater part of it dissolves, and a little naphthaline separates in flakes. The solution, when filtered and examined,

was found to contain free sulphuric acid, mixed with the peculiar acid, but being subjected to the following operations, was made to furnish the latter in a pure state.

A pure specimen of native carbonate of baryta was selected, which being rubbed in a mortar with the diluted impure acid, neutralized it, forming salts of baryta. The mere sulphate thus produced was insoluble, but upon washing the result with water, it was found that a soluble salt of baryta was present, which could in this way be easily separated. To the neutral and pure solution of this salt sulphuric acid was carefully added in quantity just sufficient to precipitate all the baryta, without leaving any free sulphuric acid in solution; filtration then separated the salt, and a pure aqueous solution of the new acid was obtained.

This solution was of a bitter acid taste, powerfully changing vegetable colours, combining with and neutralizing all bases, but not precipitating salts of baryta or lead. When carefully evaporated, either at a low temperature or in the receiver of an air-pump, it yielded the acid in a white solid crystalline form, unchangeable in close vessels at common temperatures, but deliquescing in the air. When heated to 212°, it melted, and recrystallized on cooling; at higher temperatures it gave off water, then changed colour, charred, and ultimately produced naphthaline, sulphurous acid, and charcoal.

The salts formed by this acid with bases are described in the second section of the paper. They are readily made by adding the pure acid to bases, or otherwise by neutralizing the impure acid with the bases, and then digesting the result in alcohol; the sulphates are left behind, whilst the peculiar salts (sulpho-naphthalates) are dissolved and removed. All these salts are soluble, without exception, in water and in alcohol: by evaporation of the solutions, they are obtained in a solid state, more or less crystalline, and they are generally unchanged by time or exposure to the air. When heated in the air they burn with much dense flame, leaving sulphates, mixed generally with a little of the sulphurets: the loss of weight from the dissipation of combustible matter is very great, amounting, in many of them, to one half nearly.

In the analytical experiments made on this acid and the salts, the compound with baryta was chosen, as a salt easily obtained in the pure state and very definite; after being heated to 212°, for some time it appeared to be perfectly anhydrous, but would bear a temperature of 500° without suffering any material change; it was analyzed by being heated with peroxide of copper for the estimation of the carbon and hydrogen; by being heated in the air, moistened with sulphuric acid and re-heated, for the baryta; and by being heated with a mixture of carbonate of baryta and oxide of copper, the residuum being acted upon by nitric and

muriatic acids for the sulphuric acid: operating in this way with the necessary precautions, the composition of the salt appeared to be

Baryta	78.00
Sulphuric acid	85.35
Carbon	118.54
Hydrogen	8.13

or nearly

1	proportional	Baryta . .	78
2	,,	Sulphuric acid .	80
20	,,	Carbon . .	120
8	,,	Hydrogen . .	8

and if the proportional of baryta be abstracted, it leaves the elements which compose the acid.

Hence it appears that this acid has a saturating power equivalent only to one-half of the power of the sulphuric acid it contains, and that, consequently, in these compounds, hydro-carbon, in the proportionals above mentioned, produces the same effect in that respect as a proportional of any salifiable base. A fact of a similar kind was mentioned to the author by M. Hennel, as occurring in the sulphovinous acid before he had established it with respect to the acid in question.

13. *Method of securing Wooden Buildings from Fire.*—In consequence of the destruction two years ago of the great theatre in Munich by fire, various preparations have been made by the chemists of Bavaria, fitted to destroy the combustibility of wood. The best of these appears to be that of Professor Fuchs; 10 parts of potash or soda, 15 parts of siliceous sand, and 1 part of charcoal, are melted together. This mass dissolved in water, and either alone or mixed with earthy matters, applied to wood, is said to preserve it from fire completely. A good process of this kind must be very valuable wherever houses are built of wood, and in which situations the alkali is generally abundant.—*Edin. Phil. Jour.* xiv. 200.

14. *Bi-sulphuret of Copper.*—A bi-sulphuret of copper may be formed artificially from the sulphuret produced by heating copper and sulphur together. For this purpose the sulphuret is to be rubbed in fine powder, with strong and pure nitric acid in a mortar, at common temperatures; action takes place, which, when completed, results in the production of a bi-sulphuret. This, when washed and dried, is a greenish-black powder; when heated, sulphur is evolved; and, by sufficient temperature in close vessels, the bi-sulphuret reverts to the state of sulphuret again.

Hot nitric acid decomposes the bi-sulphuret, producing nitrate of copper, sulphur, sulphuric acid, nitrous acid, nitric oxide, &c.—M. F.

15. *On the Mutual Action of Sulphuric Acid and Alcohol, and on the Nature of the resulting Compounds.*—Upon these curious subjects of inquiry, Mr. Hennell, of Apothecaries'-Hall, has lately transmitted a communication to the Royal Society, the details of which we shall reserve for a future occasion. He shews, by a series of satisfactory experiments, that what is usually called *Oil of Wine* is a compound of sulphuric acid, neutralized, as it were, by hydro-carbon; and that, when acted upon by potassa and other bases, a portion of the hydro-carbon is thrown off in the form of a thick oil, while another portion remains combined with the base and acid, constituting distinct triple salts; in these salts there exists *two* proportionals of sulphuric acid, *one* of hydro-carbon, and *one* of base,—they are soluble in alcohol; affect peculiar crystalline forms; and when duly heated, burn with flame and leave bisulphates. Mr. Hennell shews that the *composition* of the hydrocarbon is analogous to that of olefiant gas, that is, that it consists of one proportional of carbon united to one of hydrogen; but of this compound, *four proportionals*, in a peculiar state of condensation, are contained in each proportional of the saline compounds.

III. Natural History.

1. *On the Influence of the Atmosphere on the Circulation of the Blood.*—August 29, 1825. MM. Cuvier and Dumeril made a report upon the Memoir by Dr. Barry, *concerning the Influence of the Atmosphere on the Circulation of the Blood.*—This memoir has for its principal object the determination, by positive experiments, of the power by which the blood is forced and directed from the smallest ramifications into which it has been carried back again to the heart.

Whilst studying the phenomena of venous circulation, Mr. Barry was led to observe, that, by the act of inspiration, a void was made in the cavity of the chest tending to dilate it, and that all liquids in communication with the interior of the thorax should be drawn towards it, as forced by the atmospheric pressure. It must be acknowledged that all the known facts are explained by this physical effect. Of this kind are the swelling of the jugular vein during expiration, and the collapsion during the opposite movement; the cessation of certain hæmorrhages by forced inspiration; the absorption of air by the veins, and the accidents which have followed from the opening of any of the great canals near the heart.

The author does not content himself with quoting facts in support of his opinions, but has endeavoured to corroborate it by direct experiments, of which the following are the principal:—

Having fixed the end of a glass-tube, furnished with a stopcock, upon one of the large veins, as, for example, the jugular of

a living animal, and having placed the open end in a coloured liquor, he observed, after opening the stop-cock, that at each strong inspiration made by the animal, the liquid was rapidly absorbed; that on expiration it remained stationary, or occasionally slightly receded. The same effects followed whenever the experimenter introduced the tube, and this was done very skillfully, into one of the cavities of the thorax, and even of the pericardium.

In order to render the motion of the liquid absorbed more evident, Mr. Barry made use of spiral tubes, in which the space over which the fluid moved being larger, the ascent was more distinct; and to make this still more evident, he introduced into the coloured liquids some drops of oil, or bubbles of air, which facilitated the observation of their motion.

These experiments were executed with the greatest skill, and with every satisfactory precaution requisite to meet the objections which might be made. In all of them the author of this memoir, of which it is our object to relate the results, is satisfied that the motion towards the heart in the large vein is coincident with the instant at which the animal tends to form a vacuum in the breast; that the dark blood traverses the veins only during the act of inspiration; and that the venous movement is always under the influence of atmospheric pressure.

Mr. Barry is so convinced of this atmospheric action upon venous absorption, that he thinks the absorption of poisonous matter may be prevented by the application of a cupping-glass, or exhausted vessel, upon the recently-infected part, or into the interior of which any deleterious substance has been introduced.—*Ann. de Chim.* xxx. 192.

The conclusions at which Dr. Barry has arrived, with respect to the blood, are adopted by him with respect to all other fluids similarly circumstanced, and he has embodied some of his opinions upon this subject in a memoir, read before the Academy of Medicine at Paris, on the effects produced by the application of cupping-glasses to poisoned wounds.

Of this memoir no particular details have been given to the public, but the following abstract of the *Report* presented to the Academy by the committee, to which it had been referred for consideration, will give an idea of the estimation in which it is held.

The Report observes, that the principal statements contained in the memoir of Dr. Barry may be reduced to the three following: *viz.* 1st., That the immediate application of a cupping-glass to a poisoned wound will *prevent* the absorption of the poison, and avert all untoward accidents. 2d. That the application of a cupping-glass to a poisoned wound, even after a part of the poison has been absorbed, and has began to produce its proper effects upon the system, will *arrest* the progress of these events,

and prevent their recurrence so long as it is permitted to remain on the part. 3d. That after the cupping-glass has been applied to a poisoned wound for a certain time, the poison may be removed from the surface, and all unpleasant consequences averted, by simply washing the part with a little water.

The accuracy of these statements, the Report continues, was fully established before the Committee, by experiments performed with various poisons on rabbits and dogs. The influence, therefore, of atmospheric pressure on the process of absorption, may now, it is added, be incontestably proved; and the establishment of this fact, for which we are indebted to Dr. Barry, may justly be regarded as a true discovery, notwithstanding some vague ideas previously put forth by others on the subject; and the empirical practice of sucking poisoned wounds, which have been so long known to the profession.

The poisons employed, were arsenic, prussic acid, strychnia, the upas tienté, and, finally, that of the viper, the living animal being made use of. Wounds were made upon the back and thighs of full-grown rabbits, and when the blood had ceased to flow, two or three grains of strychnia, or two or three drops of prussic acid, were introduced into the wounds, and after intervals of three, five, and ten mintutes, a cupping-glass was applied, which was renewed as often as it fell off. No symptoms of poisoning occurred in these cases, but if the precaution was neglected, death ensued.

A cupping-glass applied to a wound, into which some strychnia had been put, prevented the effects of this substance from manifesting themselves, and also suspended them when beginning to be apparent. Eight grains of white arsenic were introduced into a wound in the thigh of a dog; three-quarters of an hour after, a cupping-glass was applied to the wound, and kept on for four hours, and the animal suffered no inconvenience. Another dog similarly poisoned, and left unassisted, died at the end of fifteen hours.

Six drops of prussic acid were poured into a little wound, made in the thigh of a rabbit; the cupping-glass was applied for twelve minutes, and the animal shewed no signs of having been poisoned; but when it was taken away, convulsions came on so suddenly that it was thought to be dead, but a fresh application of the cupping-glass restored it to its former state of tranquillity; the same effects ensued upon removing it again, and it was only half an hour after the introduction of the poison that it could be removed with impunity. Another rabbit, treated with the same quantity of acid, where no cupping-glass was used, died in two minutes.—*Med. Rep.* ii. 176. *Med. Jour.* lv. 67.

2. *Champooing, as practised at the Tonga Islands.*—If, during

the day, a chief, or other person of rank feels fatigued with walking or any other exercise, he lies down, and has one or more of the following operations performed upon him by some of his attendants, viz., *toogi-toogi*, *mili*, or *fota*. Of these terms the first implies, *a constant and gentle beating with the fist;* the second, *a rubbing with the palm of the hand;* and the third, *a compressing and grasping of the integuments with the fingers and thumb.*

These operations are generally performed by females, and all contribute, we are assured, materially to relieve pain, lassitude, and fatigue; producing at the same time a soothing effect upon the system, and a disposition to sleep.

When performed for the purpose of simply relieving fatigue or lassitude, the legs and feet, it would appear, are the parts generally operated upon; but in cases of local pain, the part affected, or its immediate neighbourhood perhaps, is selected. Thus in headach, the skin of the forehead, and the scalp in general, is subjected to the *fota*, and often, we are told, and indeed we have no doubt, with great effect.

Sometimes also, in cases of fatigue, a proceeding somewhat different from any of these is adopted; three or four little children being employed to trample upon the body all over with their feet, to the great relief and comfort of the patient, who lies stretched naked on the ground.—Mariner's *Tonga Islands*, 2d Edition, ii. p. 342.

3. *Consumption of Food in Paris for* 1824.

Beverages.	Wine	hectolitres	967,465	25559457.8	galls.
	Spirits	,,	53,314	1408502.5	,,
	Cider and Perry	,,	12,023	317635.6	,,
	Vinegar	,,	19,383	512079.5	,,
	Beer	,,	154,405	4079225.7	,,
	Raisins	half kilogrammes	2,344,360	2587001.2	lbs.

Eatables.	Oxen		79,627		
	Cows		10,941		
	Calves		76,811		
	Sheep		383,807		
	Pigs and boars		89,110		
	Viande à la main,	kilogrammes	1,397,452	3084176.5	lbs.
	Offal, &c.	,,	714,069	1575950.3	,,
	Cheese	,,	1,451,032	3202427.6	,,
	Fresh sea-fish	,,	4,110,008	9070787.6	,,
	Oysters	francs	1,013,608		
	Fresh-water fish	,,	633,082		
	Poultry and game	,,	8,701,510		
	Butter	,,	4,573,061		
	Eggs	,,	4,230,942		

Provender. Hay	trusses	9,231,590		
Straw	,,	15,077,840		
Corn	hectolitres	1,181,007	.	31201024 galls.

The corn and flour sold at the market-place is not included in this table, inasmuch as these sales do not give the real consumption of the town: it is estimated at 1500 sacks, of the weight of 159 kilogrammes each, per day.

When the price of bread is higher out of Paris than in the town, then nothing is brought in; but, on the contrary, food is taken out: the daily consumption then has no rule, and, at times, is above 1700 sacks.—*Ann. de Chimie*, xxx. 440.

4. *Salivary Calculus.*—A calculus about the size of the fist was extracted from the canal of Stenon, in a living ass, by M. Gravost of Corbiel. It was oval, white, polished, about the hardness of marble, and weighed 620 grammes (9575 grains). When sawn across, it exhibited a succession of layers, white as alabaster, but no nucleus. Its specific gravity was 2.302.

Upon chemical examination it was found to consist of

Water	3.6
Soluble matters of saliva (soda, animal matter, soluble in alcohol, muriate, sulphate, lime, &c.)	1.0
Animal matter analogous to mucus	6.4
Phosphate of lime and traces of oxide of iron	3.0
Sub-carbonate of lime	85.1
	99.1

Ann. de Chim. xxx. 332.

5. *Comparison of Indian and European Sculls.*—Dr. Patterson of Calcutta, from a comparison of numerous sculls of Indians with those of Europeans, has deduced that the head of the former is to that of the latter race, as two to three. Or otherwise, that the head of an European fifteen years of age, is of the same size as the head of an Indian thirty years of age.—*Rev. Ency.* xxviii. 939.

6. *Diminution of the Goitre in the Pyrenees.*—When presenting a memoir on Goitres, by M. Roulin of Bogota, to the Academy, M. Majendie who has lately traversed the Pyrenees, stated that this disease is much less frequent than heretofore. This amelioration, according to him, is caused by the increased riches of the inhabitants, to the extended culture of grain, and to the better construction of the houses. M. Mongey remarked on this subject, that M. Fabroni thought he had observed that the granitic valleys only of the Pyrenees were exempt from the goitre.—*Ann. de Chim.* xxx. 316.

7. *Sounds produced under Water by the Tritonia Arborescens.*—

Dr. Grant has remarked the production of sound by these animals under water. The sounds they produce when in a glass vessel, resemble very much the clink of a steel-wire on the side of the jar, one stroke being given at a time, and repeated at intervals of a minute or two. The sounds are obscure, when the animal is placed in a large basin of water, but in favourable circumstances they may be heard at the distance of twelve feet. They are longest and most frequent when the *Tritoniæ* are lively; no globule of air escapes to the surface of the water, nor is any ripple observed there. The sounds obviously proceed from the mouth of the animal, and at the instant of the stroke the lips are suddenly observed to separate, as if to allow the water to rush into a small vacuum formed within. Dr. Grant has preserved these animals alive for a month together, giving them fresh water every day, and occasionally fresh branches of the *Sertularia dichotoma.* They have continued to emit sounds during the whole of the period.—*Edin. Phil. Journ.* xiv. 185.

8. *Account of the Sea Fish in Mr. Arnold's Pond in the Island of Guernsey.*—The following account has been transmitted to us by Granville Penn, Esq., who received it from Capt. H. Forbes, R.N. Capt. Forbes obtained it on the spot, and also brought away a portion of the water, having himself procured it from the pond. The proportions of saline contents in it as compared with the contents of sea-water from Brighton is as follows:

1 pint of the pond-water yielded 44 grs. of dry salts.
1 pint of sea-water yielded 268 grs. of dry salts.

We refer our readers for highly interesting information on this subject, to Dr. Mac Culloch's papers, the one at page 15 of this volume, the other at page 237, vol. xix.

Mr. Arnold's pond is at all seasons fed by two fresh-water streams, which, however, during the summer months, yield but a trifling supply of water, except indeed, after heavy rains. On the other hand, the sea-water gains admittance every spring tide, and thus increases the level of the pond about three inches; it follows of course, that the pond is at all times more or less *brackish.* The different species of fish which inhabit it are, the turbot, the sole, the plaice, the gray-mullet, the barce, the eel, the loach, and the smelt, with the addition of the crab and shrimp: each of the fish above-named is found to possess a greater weight in proportion to its size, than when caught in the sea, and to be perfectly well flavoured. No oysters have hitherto been put into the pond, but the experiment is shortly to be tried.

9. *Colossal Sponge discovered at Singapore, Asia.*—A production has been discovered in the Island of Singapore, lately inhabited by the English, which has been considered as a marine plant, and by the Indians called *sounge.* It has the form of a cup or rather

of a goblet, supported on a cylindrical foot expanded at the base, and attached to the soil of the shore by an irregular expansion. It is composed of tubes or cellules of various diameters, the apertures being covered with radiated cotton-like fibres. The circumference of the cup at the upper part is 4 feet 3 inches; at the middle it is 3 feet 1 inch, and at the bottom only 22 inches and a half; the circumference of the stem at the foot is 17 inches. The cavity of this singular vase can contain 36 quarts. Colonel Hardwicke has ascertained that this production is a sponge formed by marine animals, and analogous to that which is described in the *Wernerian Transactions* under the name of *scypha*, with the exception of difference in dimension. This sponge is not flexible like the officinal species, and the name of *spongia patera* has been proposed for it. A. Moreau de Jonnes.—*Rev. Ency.* xxviii. 603.

10. *Effects of Light on Plants.*—The following experiment was lately made by Mr. Henry Phillips, to show the different effects of natural and artificial light on plants. He selected plants of the *mimosa elegans*, *nova* and *decurrens*, whilst their pennated leaves were fully expanded. On placing them in a dark room, the leaves almost immediately collapsed like the sticks of a fan, or as the feathers of a bird's wing fold over each other. The strongest artificial light which could now be thrown over them, had no effect on the automatic motion of the plants, and the foliage remained in a collapsed state until they were removed into the natural light of day, when their sensitive properties immediately became perceptible, and the whole of the leaflets were seen moving towards their natural and elegant direction, with as much regularity as a regiment of soldiers file off at the word of command.—*N. M. Mag.* xviii. 12.

11. *Method of clearing Trees from Worms, Caterpillars, &c.*—The following method of driving worms, caterpillars, and all other sorts of insects from trees has lately been practised in America, with singular success:—Bore a hole into the trunk of the tree, as far as the heart; fill this hole with sulphur, and place in it a well-fitted plug; a tree of from four to eight inches diameter requires a hole large enough to admit the little finger, and in the same proportion for larger or smaller trees. This will usually drive the insects away in the course of forty-eight hours, but uniformly succeeds, perhaps sometimes after a longer period.—*Silliman's Journal.*

12. *Hetepozite and Huraulite.*—*Hetepozite* is a mineral found at Hureaux, commune de St. Sylvester, Haute Vienne. It occurs in hard or soft portions, of a violet or yellowish-brown powder, fusing before the blow-pipe into a black globule. Analyzed

by M. Vauquelin, it proved to be a phosphate of iron and manganese.

Oxide of iron	. .	35.5
Oxide of manganese	.	16.5
Phosphoric acid	.	48

Huraulite is a rose-white mineral, lightly crystalline in the cavities, and fusing before the blow-pipe into a black enamel. It also proved to be a phosphate of iron and manganese, and, according to M. Vauquelin, contains

Bases (iron and manganese)		47.2
Phosphoric acid	. .	32.8
Water	. . .	20.0

Ann. de Chim. xxx. 294-302.

13. *Transmission of finely-divided Matter by the Wind.*—The following instance was communicated to the Editor of the *Ann. de Chim.* (xxx. 430.) by M. Schabelski, an eminent Russian traveller. "When the vessel was in the latitude of 23° N. and long. 21° 20′ W. of Greenwich, we were witnesses of a very remarkable phenomenon. On the morning of Jan. 22, 1822, being then 275 nautical miles from the coast of Africa, we perceived that all the cords of the vessel were covered with a pulverulent matter, resembling, in its reddish colour, that of ochre. These cords seen in the microscope presented long rows of globules, which seemed to touch. It was only those parts which had been exposed to the action of a north-east wind which presented this phenomenon, there was no trace of powder on the opposite face. The powder was very soft to the touch, and coloured the skin red.—See also *Quarterly Journal*, xix. p. 362.

14. *On the Transparency of the Air previous to Rain.*—At the meeting of the Helvetic Society of Natural Sciences, at Soleure, July, 1825, a Memoire by M. de Luc, of Geneva, was read, on the transparency of the air as a prognostic of rain, and on the fluids, &c., which diminish this transparency. The author cited many observations, proving that, in general, an extraordinary transparency of the atmosphere, with a pure sky, is followed, in the course of some hours, by an abundant rain. He thinks it may be concluded, that it is not the greater or smaller quantity of aqueous vapour mixed with the atmosphere, which alters more or less its transparency, but that the effect is due to some other kind of vapour, to which he has given the name of *dry vapour*. He quotes, as examples of this kind of vapour, that which extended over a great part of Europe in 1783, and which did not affect the hygrometer; and he ranges in the same class those which frequently confer a misty tint on the air, without giving apparent signs of humidity. These vapours are frequently the precursive signs of a thunder-storm, and the author thinks that they have some connexion with the electric fluid.—*Bib. Univ.* xxx. 164.

Art. XV.—METEOROLOGICAL DIARY for the Months of December, 1825, January, and February, 1826, kept at Earl Spencer's Seat at Althorp, in Northamptonshire.

The Thermometer hangs in a North-eastern Aspect, about five feet from the ground, and a foot from the wall.

For December, 1825.

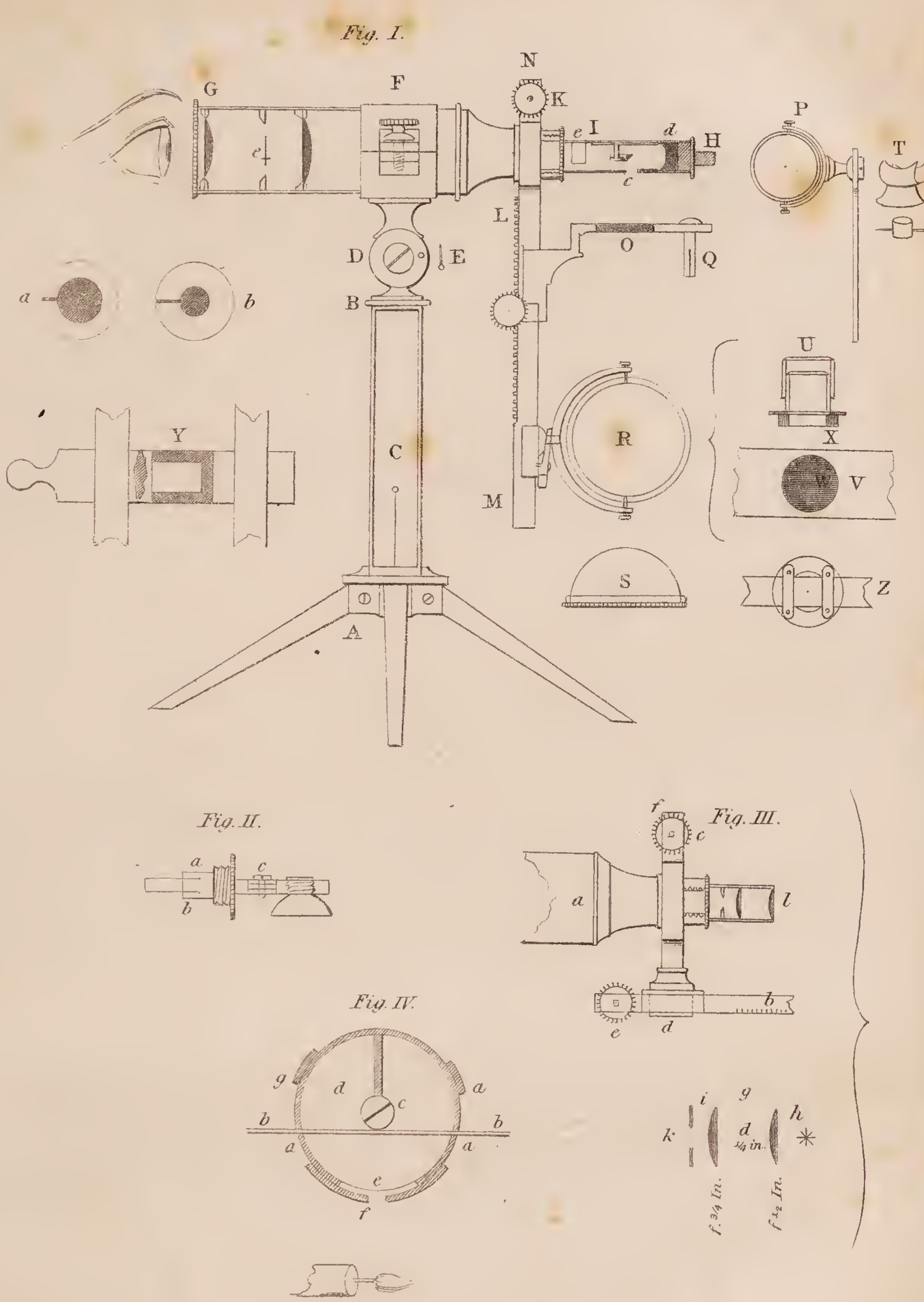
	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Thursday - - 1	21	34.5	29.50	29.30	E	ESE
Friday - - - - 2	22.5	42	28.84	28.84	SE	WbS
Saturday - - 3	31	43	28.97	29.10	WbS	W
Sunday - - - 4	31.5	42	29.06	29.18	W	WbN
Monday - - - 5	27	40	29.27	29.16	WNW	NE
Tuesday - - - 6	35	47	29 16	29.20	SSW	E
Wednesday . 7	39	47	29.12	29.12	E	E
Thursday - . 8	38	42	29.20	29.23	E	NE
Friday - - - . 9	41	43	29.26	29.40	NE	NE
Saturday - . 10	42	43	29.50	29.50	NW	W
Sunday - - . 11	41	44	29.50	29.51	W	W
Monday - - . 12	30	40	29.73	29.70	SW	SW
Tuesday - - . 13	28.5	45	29.64	29.50	SW	SW
Wednesday . 14	45	50	29.20	29.20	SE	SW
Thursday - . 15	33	38	29.49	29.58	W	SSW
Friday - - . 16	35	49	29.50	29.68	WbS	WsW
Saturday - . 17	45	51	29.58	29.62	WbS	W
Sunday - - . 18	36	51	29.51	29.42	SW	WSW
Monday - - . 19	40	48	29.21	29.21	SE	SbW
Tuesday - - 20	34	56	29.30	29.25	E	ESE
Wednesday - 21	43	48	29.28	29.31	SE	SE
Thursday - - 22	41	47	29.37	29.57	WbN	W
Friday - - - - 23	36	42	29.70	29.61	SW	W
Saturday - - 24	33	42	29.90	29.92	W	W
Sunday - - - 25	34	49	29.60	29.72	WbS	W
Monday - - - 26	34	42	29.75	29.67	W	NW
Tuesday - - - 27	25.5	35	29.76	29.71	WNW	NW
Wednesday . 28	25.5	36	29.59	29.51	WbN	NW
Thursday - - 29	32	36.5	29.47	29.49	NW	NW
Friday - - 30	28	34	29.50	29.50	NW	NW
Saturday - 31	21	30	29 60	29.62	W	W

For January, 1826.

	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Sunday - - - 1	18	40	29.62	29.56	SE	SE
Monday - - - 2	34	40	29.63	29.68	SE	E
Tuesday - - - 3	30	36	29.70	29.74	EbS	EbN
Wednesday . 4	33	34	29.81	29.80	EbN	NE
Thursday - - 5	32	34	29.80	29.81	NE	ENE
Friday - - - - 6	31	34.5	29.72	29.62	NE	E
Saturday . 7	32.5	34	29.74	29.74	E	EbN
Sunday - - . 8	26.5	31	29.84	29 90	NE	E
Monday - - . 9	19	28	29.96	29.90	E	E
Tuesday - - - 10	16	31	29.74	29.59	W	W
Wednesday - 11	22	31	29.59	29.61	NW	NW
Thursday - - 12	16.5	29	29.70	29.70	WbN	WbN
Friday - - - - 13	16	27	29.84	29.86	WbN	NW
Saturday - - 14	13	28	29 97	29.97	W	W
Sunday - - - 15	8	27	30.14	30.23	W	WbN
Monday - - 16	8	26	30.32	30.38	WbN	WbS
Tuesday - - - 17	16.5	33	30.38	30.38	S	SbW
Wednesday - 18	26	37	30.32	30.17	SW	WbS
Thursday - - 19	36	40	30.00	29.98	W	NW
Friday - - - 20	31	39	30.00	30.02	N	NW
Saturday - - 21	33	41	30.00	29.97	NW	W
Sunday - - - 22	31.5	38	30.07	30.06	WbN	W
Monday - - - 23	31	41	30.00	30.10	W	WNW
Tuesday - - - 24	25	34	30.20	30.21	WbN	WbN
Wednesday - 25	29	37	30.18	30.13	WbS	SE
Thursday - - 26	30.5	34.5	30.13	30.13	E	E
Friday - - - - 27	30	35	30.10	30.05	SE	WbS
Saturday - - 28	28	38	30.09	30.03	W	S
Sunday - - - 29	23	40	29.88	29.80	SE	SE
Monday - - 30	33	42	29.65	29.49	SE	SE
Tuesday - - 31	38	47	29.49	29.49	S	S

For February, 1826.

	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Wednesday - 1	39	43	29.63	29.63	SbW	S
Thursday - - 2	40	39.5	29.60	29.60	SW	SW
Friday - - 3	46	48	29.50	29.42	S	SW
Saturday - - 4	33	44	29.60	29.70	SW	SW
Sunday - - - 5	36	50	29.64	29.53	SW	S
Monday - - - 6	43	53	29.30	29.27	S	SW
Tuesday - - - 7	41	47	29.67	30.00	W	W
Wednesday - 8	26	43	30.10	30.10	SW	SW
Thursday - - 9	26	42	30.10	30.05	SW	SW
Friday - - - - 10	28	36	30.05	30.05	SE	SE
Saturday - - 11	30	40	29.98	29.90	ESE	SE
Sunday - - - 12	35	49	29.87	29 87	SE	S
Monday - - - 13	27	47	29.90	29.81	SbW	SW
Tuesday - - - 14	36	49	29.69	29.73	SW	SE
Wednesday - 15	43	49.5	29.73	29.67	SE	SE
Thursday - - 16	44	51	29.56	29.54	SSE	S
Friday - - - - 17	41	47	29.11	29.27	WSW	WbS
Saturday - - 18	30	42	29.49	29.60	SSW	SW
Sunday - - - 19	33	51	29.29	29.37	WbS	SW
Monday - - - 20	39	46	29.48	29.80	W	W
Tuesday - - 21	33	47	30.02	30.10	WbS	SW
Wednesday - 22	40	53	29.78	29.67	SW	W
Thursday - - 23	38	46	29.67	29.67	WbS	W
Friday - - - - 24	29	40	29.90	29.94	W	SW
Saturday - - 25	36	53	29.80	29.87	W	W
Sunday - - - 26	32.5	46	30.17	30.21	WbS	WbS
Monday - - - 27	36	50	30.10	29.87	WbS	W
Tuesday - - 28	36	53	29.95	30.00	W	WbS



The Improved Amician Engiscope.

C.R. Goring del.

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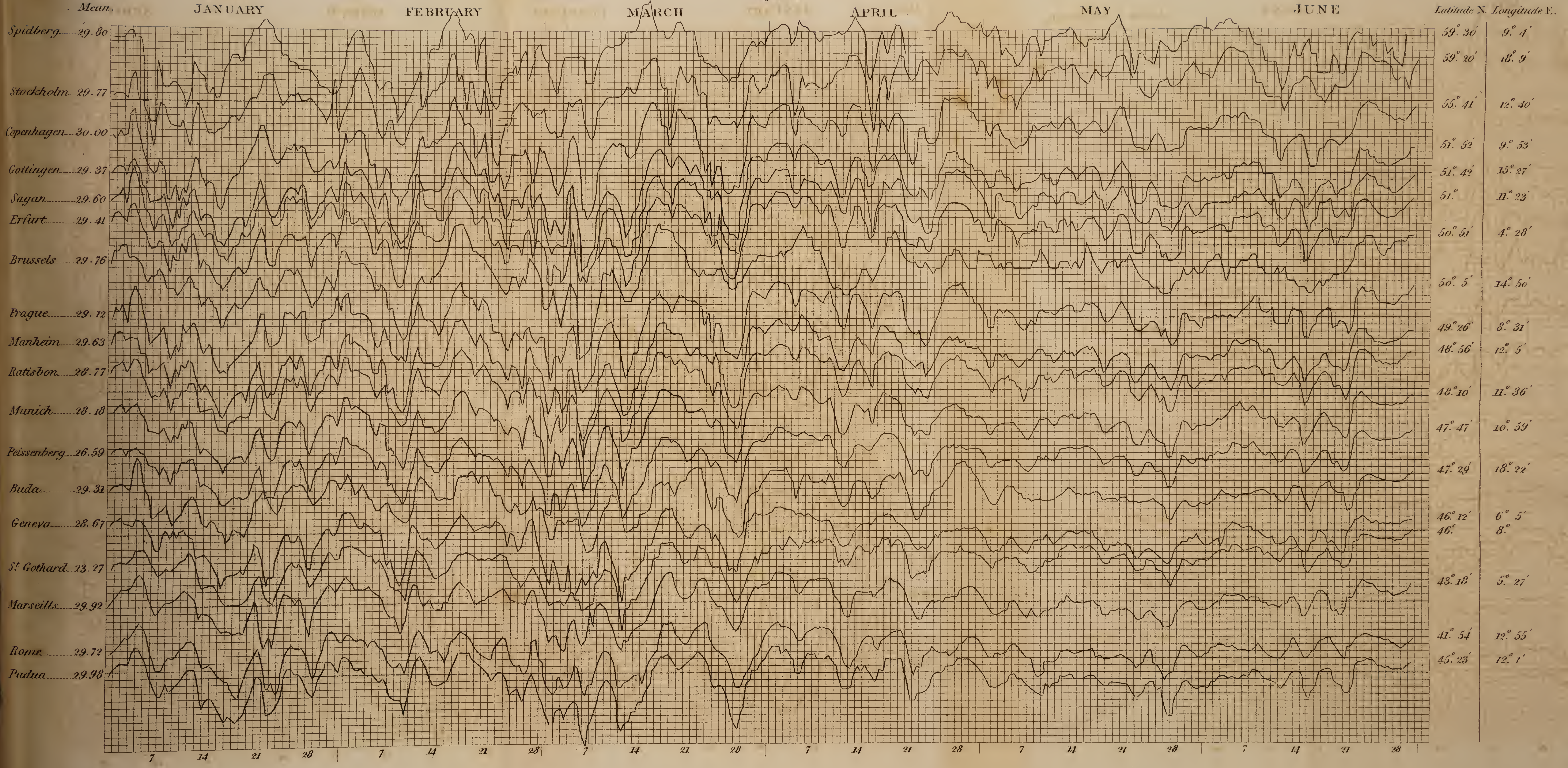
Plate II. vol. XXI.

OSCILLATIONS OF THE BAROMETER.

1783.



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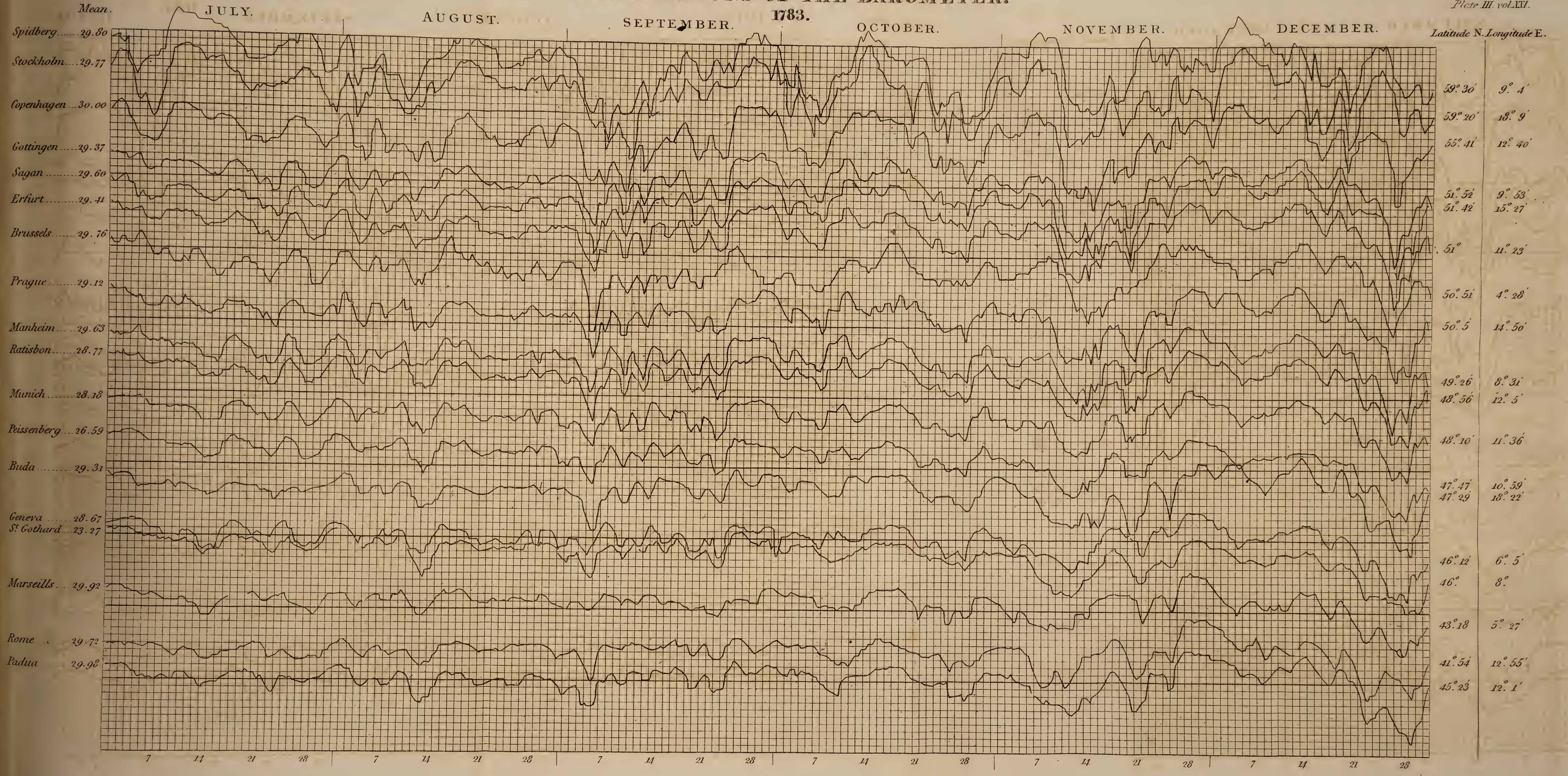

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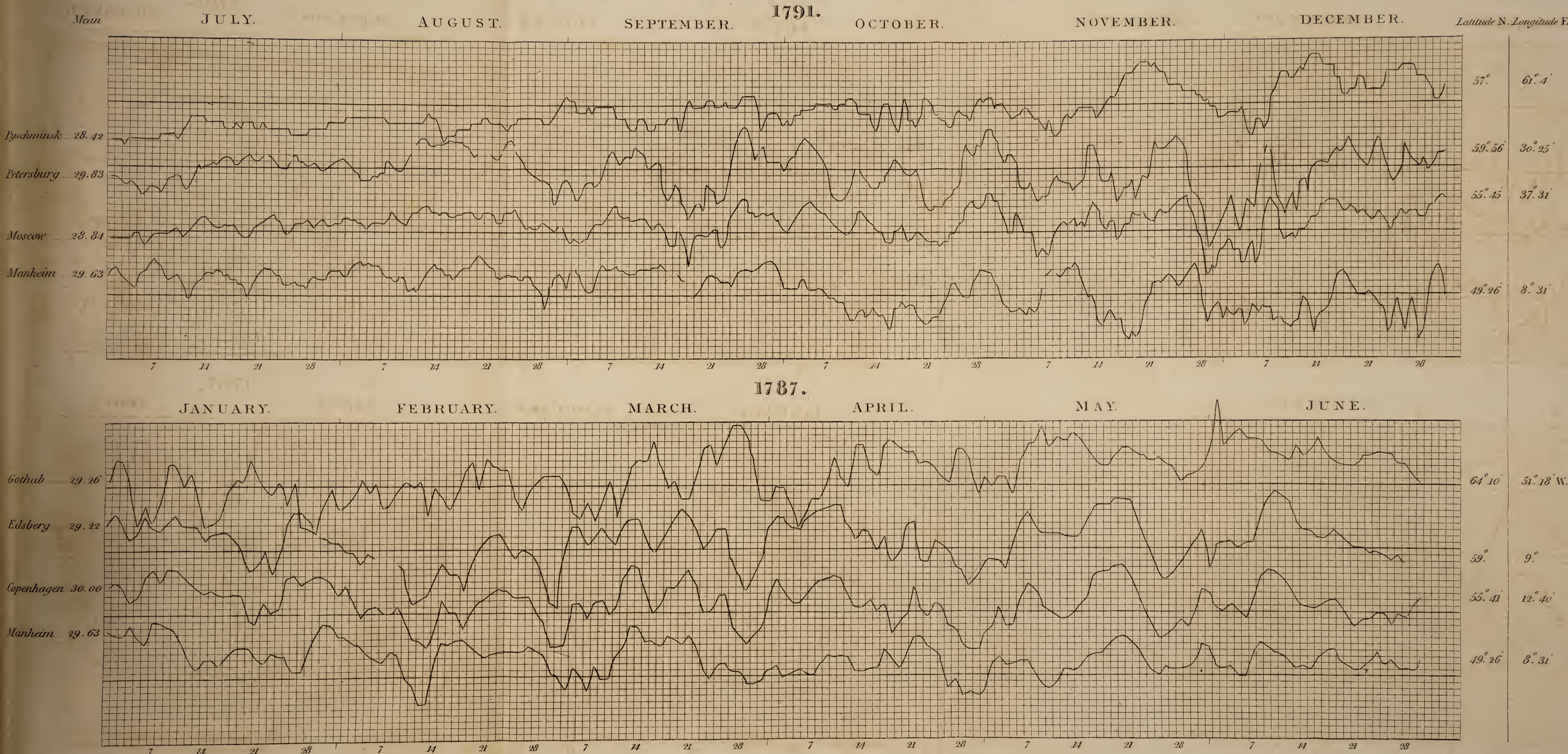

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July, 1826.

Art. I.—*Observations on the Plans of Education followed at the Military Academies of New York and of this Country.*

[From a Correspondent.]

We feel ourselves identified, in so many respects, with our Western brethren, that we could not read without interest the account lately given, in the *Quarterly Journal*, of the Military Academy at New York. Viewing it merely as a military establishment, we regard its existence as a proof that, even in a country which, by its situation, cannot have much to fear from the encroachments of an enemy more powerful than itself, and in which the government is professedly democratical, such an institution has been thought necessary for the purpose of training its sons in the art of war, and not incompatible either with the liberty of the subject, or with economy in the disposal of the national revenue.

The building is described to be of rubble-stone, and without any pretensions to architectural embellishment; a circumstance which we consider as of little moment in a place intended to be for the purposes of education, except as far as a magnificent edifice adds an ornamental feature to a country. No doubt, those who were intrusted with the determination of the spot where the establishment was to be formed, have, in their choice of West Point, availed themselves of the few circumstances which the soil of the United States affords to excite an enthusiastic feeling in

the minds of the pupils; and it is, perhaps, not much to be regretted by the people, that they want the excitement to military ardour which is derived from a view of scenes where the warlike achievements of a remote ancestry have been exhibited.

But that which most concerns us is the consideration of the plan of study pursued at the academy of New York, that we may compare it with what is practised at similar institutions in this country. We find that the pupils enter at fourteen years of age, and continue there four years; and it is probable that the acquirements of most of them previous to their entrance are confined to the art of writing and the first rules of arithmetic. Now, knowing the dispositions of boys at that age, the difficulty with which they can be brought to apply themselves to abstract meditation, and the necessity for considerable relaxation from study, even in the most industrious, it seems that the course of instruction is much too extensive to be completed within the time prescribed. We find, indeed, an admission in one place, that the education of the cadets is more remarkable for the variety of the subjects it embraces, than for the depths to which they are pursued, even by the most advanced pupils; and this is what might be expected; but we do not know how to reconcile that fact with what is asserted in another place, *viz.*, that whatever is taught, is taught thoroughly.

It is not meant, however, to deny that there are boys who have had the advantage of extraordinary instruction, and who might, at the age of fourteen, enter the establishment with a complete knowledge of plane and solid geometry, and of the resolution of simple equations, in addition to the rules of arithmetic; but there must be few of these, and, even with this preparatory instruction, four years are too short a time to accomplish a course like that which is here laid down.

The cadets begin with algebra, and proceed to geometry. Now this arrangement is the reverse of that which is usually adopted, if a geometry similar to that of Euclid is meant; which seems to be the case, because analytical geometry is mentioned afterward, and we cannot wholly approve of it, since, to teach the ancient

before the modern analysis would seem to correspond better with the order in which our faculties are developed.

The cadets next enter upon plane and spherical trigonometry, which are taught according to the analytic method, and proceed to surveying and perspective. They are afterward taught the properties of the conic sections, and the differential and integral calculus, both from La Croix and Bourhalot. This is already going far, but it not being considered sufficient, they study fluxions from Dr. Hutton's course. Now if the particular calculus employed by the mathematicians of the continent of Europe is taught, it is but fair that the pupils should also learn that kind which was employed by the great discoverer himself, and by the eminent men who have followed him in England; but to use the very elementary portion of fluxions contained in Dr. Hutton's course, after studying La Croix, seems like going back to the horn-book after having learned the grammar of a language. However, all this, and analytical geometry, perhaps from such a work as that of Francœur, seems to be got over in the second year, for the two last years are devoted to Natural Philosophy, Chemistry, Drawing, &c. But we must take the liberty of observing that, if some part of the two last years had been employed in a more elementary trigonometry and the arts which are immediately connected with the military profession, instead of so much of the infinitesimal calculus, the pupils would be found, at the age of eighteen, more competent to discharge with advantage the duties which they may be called upon by their country to perform.

We cannot believe that the most effectual way of teaching the elements of mathematics is by the analytic method, of which it has been justly remarked, that a long train of reasoning may be carried on by it without having a clear idea, or even without having any idea whatever of the subject under consideration. The ancient geometry is useful not merely in disciplining the mind to habits of correct thinking, but, when employed as a means of discovery, it has the advantage of keeping constantly in view the dependence of the steps upon the object of research. The modern analysis affords a mechanical facility in the investigation of pro-

positions, and must be employed where the other would fail, or become too operose; but it ought not, on that account, to supersede it entirely.

In all institutions of this nature, there must necessarily be a similarity in the course of study, and in the police of the establishment. In our country there are two such colleges, under the patronage of government; *viz.*, one at Woolwich, for the education of officers for the regiments of artillery and engineers, and the other at Sandhurst, for officers of the line. To the benefit of a salubrious climate are added, at both these places, every convenience of interior arrangement, with the pleasing impressions produced by a display of architectural taste in the simple majesty of the buildings, so well according with the purposes for which the institutions are intended.

In England, and in the present age, the general sentiment being so much in favour of a classical education, that, except at the universities, little attention is paid to the sciences in any of the schools, public or private, it is easy to conceive that youths who join these establishments seldom come prepared with anything beyond the rules of arithmetic: these, indeed, are required of them, and, as they are to be brought up to a profession, the highest branches of which are founded upon mathematics, it is necessary that particular attention should be paid to this part of education, without, however, leaving the classics neglected: and it will be allowed by those who have had an opportunity of witnessing the mode of conducting the education of cadets at the English military schools, that the aim has rather been to give a perfect knowledge of such parts of the mathematical course as are absolutely necessary, than to pass over them superficially for the sake of obtaining an ill-founded reputation, by forcing the pupil into others, the utility of which is remote and doubtful. In conformity with this view, the cadets, after completing the course of arithmetic, are made thoroughly masters of both plane and solid geometry; they proceed then to plane trigonometry and mensuration, in conjunction with which they are taught practical geometry on the ground, surveying, levelling, and topographical drawing; they afterward

study the properties of conic sections, spherical trigonometry, algebra, and either fluxions or the differential calculus; the best English works on the several subjects being taken as text-books in the halls of study; and from one class the cadets proceed to another, according to their merits, which are ascertained by monthly examinations. The evil complained of at the academy of New York does not exist in this country, *viz.*, that the practical uses of mathematics are not sufficiently insisted on, for the studies of fortification and artillery, including those of the arts connected with them, are carried on both theoretically and practically, by the aid of the best foreign and English works on those subjects, and the instruction is facilitated by accurate models, where real examples cannot be obtained. In addition to these applications of pure mathematics, those cadets whose progress in the previous course has been such as to render them qualified, are allowed to attend lectures on natural philosophy and astronomy, in which the subjects are illustrated by an extensive and valuable apparatus.

In the English military schools much stress is laid upon the art of representing ground on paper; and the utility of this is obvious, as it teaches the pupil to acquire an accurate and ready eye for distinguishing the character of a country: he becomes thus enabled to avail himself of all the favourable circumstances that the localities afford in the choice of military positions, and to ascertain the resources which a country may furnish for the support of an army or detachment marching through it. Many specimens which we have seen of these drawings, possess an unrivalled beauty of execution.

But a British officer does not cease to be a citizen because he carries arms, and the education of a gentleman renders him an ornament to society and to his profession. The military colleges of this country, therefore, provide for him ample instruction in classics and in the modern languages; he is carefully taught both ancient and modern history, geography and drawing, and the strictest attention is paid to his moral and religious conduct.

In the intervals of his studies, and as a necessary relief from his occupations within the walls of the building, the cadet is daily

instructed in all the detail of military discipline and evolutions, under an extensive and meritorious staff; he is taught the indispensable art of riding, and his muscular system is strengthened by the performance of gymnastic exercises.

Finally, a half-yearly examination takes place before a board of military commissioners, when such cadets as have completed the course, and can pass satisfactorily, are recommended for commissions.

Such punishments as it is necessary to inflict are of a military kind; they consist in being obliged to keep guard, in confinement within certain bounds, in a dark room, or, finally, which however rarely happens, expulsion from the establishment.

The daily application to the duties which have been mentioned occupies the time and minds both of the cadets and their instructors so completely, as to be just within the limits beyond which it would produce an exhaustion detrimental to the improvement of the one party and the health of the other; and experience has shewn that the pupils cannot, to any good purpose, go through a more extensive course within the period allowed for their continuance at the colleges. In what is called the senior department at Sandhurst, indeed, which consists of a certain number of officers who have already served their country some years, and who are educated for staff situations, the pupils joining the establishment with the advantages of a previous education, are enabled to pursue their studies further. These, after completing the course which is prescribed to the junior department, are taught as much of the Principia as is necessary to prepare them to enter upon the studies of physical astronomy and natural philosophy, in which they are afterward instructed according to the analytic method. An observatory, furnished with sufficient instruments for the purposes of instruction, enables them to unite practice with theory, and qualifies them for those duties which, in the course of their service, they may be called upon to perform.

If it were permitted to go for a moment into the general question of the utility of a scientific education, it might be alleged that the simplest proposition of geometry leads to the determina-

tion of the angular distance of the heavenly bodies, and this enables us to ascertain the situation of a ship on the pathless ocean, by which all the benefits of a mutual intercourse between distant nations are obtained. But it is not merely in navigation that we find the sciences employed, for the highest departments of them are subservient to the construction of a path across a rapid river, which, while it permits the traveller to pass in safety, permits also vessels to float under it without impediment. The sciences are also applied in the formation of such works as canals and docks, for this involves the knowledge of the strength of materials, the theory of pumps, steam engines, and every other contrivance for draining ground, raising and lowering heavy bodies, and the like. By mathematical principles we are enabled to assign such constructions of ships and other floating bodies, that the water may present the least resistance to their motion, and avail ourselves of any circumstances which may lead to improvements in the machinery employed in the manufactories, upon which our national wealth so much depends.

What has been said of the utility of the sciences to men in general applies particularly to those who are engaged in the practice of military engineering, which comprehends the art of constructing permanent and temporary works for the purposes of attack and defence, and for facilitating the communications of armies with their points of support; and in addition to the rules by which these objects are to be accomplished, we derive from analysis the formulæ for determining the velocities and ranges of shot and shells, which, within certain limits, is of considerable importance.

But the soldier's destiny often leads him to a foreign station, where he may render essential service to his government and to science, by determining the geographical positions of places, by observing the refractive power of the atmosphere, the phenomena of tides, the elevation of mountains, the variation of the magnetic needle, and the principal circumstances in the department of meteorology. He may, to a certain extent, examine the structure, and collect data for ascertaining the form of the earth;

the opportunity of doing all which would be lost without an education expressly directed to these objects.

Time, by shewing our wants, will perhaps bring on improvements in the military education both of this country and America; a few years since, the sciences which are the subjects of military instruction being little studied by gentlemen of that profession, the necessity of them was little felt; but, in proportion as they are cultivated, new wants are discovered; and to give to the system of education all the efficiency of which it is capable, much yet remains to be done: but we may, perhaps, safely leave this to the progress of events, which will in due time bring to light all our defects; and no doubt, when these are ascertained, the enlightened government of either nation will hasten to adopt such measures as shall be found necessary to supply them.

Art. II.—*On the Naturalization of Plants, with Remarks on the Horticulture of Guernsey. By* J. Mac Culloch, M.D., F.R.S., *&c.*

[Communicated by the Author.]

Those who have interested themselves in horticulture have been long aware of the belief that those plants, not belonging to our own climate, which have been propagated by cuttings, retained the tenderness or delicacy of the original parent, while that, if produced from seeds, they became comparatively hardy, and might, in a certain number of successive generations, become perhaps as hardy as our native vegetables. The observation of Sir Joseph Banks, by which this opinion was chiefly confirmed, was, I need scarcely say, the propagation, in this manner, of the Zizania aquatica: my own, by which it seemed to be still further confirmed, related to the Canna indica principally, but to some other herbaceous plants and shrubs also, which, after having been long confined to the greenhouse, had been placed out of doors in Guernsey.

I have now to remark that the same opinion seems to have been

still further confirmed since that date, by more trials of the same nature; and the object of this paper is to relate the several facts or to name the plants in question, accompanying them by any remarks that may possess an interest on this subject. But I must not here conceal that the opinion in question, as to our power over plants in this manner, is not by any means so demonstrated that it must be erected into a law. There are some cases in which no such results have taken place, others in which the gain in point of hardiness is doubtful; while, I believe, I may safely add here the opinion of Mr. Sabine, that, if I mistake not, the whole is a fallacy (I hope I do not misrepresent his opinion): lamenting, at the same time, that there should be such high authority for a belief so little consolatory, for what, if really true, will deprive us of many expected sources of pleasure.

However, till the demonstration of the fallacy of this opinion is completed, it would be bad policy not to persist in the same trials, when we consider the advantages that would be derived from them, should they be true, even in a small number of cases. If it should happen, as may yet turn out the fact, that there are plants in which this succeeds, though there are others in which it fails, from circumstances in their several constitutions yet unknown to us, the effect of admitting the general or universal fallacy of the opinion would be to paralyze all future efforts, and with this also, perhaps, to limit our general attempts as to that natural hardiness in which some plants differ from others, although natives of the same climate.

This last fact seems unquestionable, in whatever way it is to be explained: and it is chiefly from want of attention to it, that so many plants were so long, and so many yet are, imprisoned in our greenhouses and stoves, when capable of bearing the free climate, and thriving, in fact, far better in the open air. The mere knowledge of all these, which can only be the result of trial, would be a considerable gain, not merely as a question of economy with respect to buildings and fire, but from the additions they would make to our gardens and shrubberies.

And it is partly for the purpose of increasing those trials that

the present paper is drawn up; as, should it even prove that the progeny from seed is not, in the majority of cases, really hardier than the parent, there will still perhaps be pointed out to English gardeners some plants, out of the whole list, which are still treated with unnecessary suspicion and tenderness.

I am aware, however, that the rules which hold in Guernsey will not hold universally in England, however they may suit the southern coasts in general, from Penzance even to Southampton, and perhaps still further east. Yet in some of the cases formerly enumerated (in the transactions of the Caledonian Horticultural Society), the result was, a considerable success, in some parts of Scotland, as to the exclusion of many plants from the greenhouse, respecting the *necessary* tenderness of which no gardener had ever doubted. Should but a few plants more be thus gained for the shrubbery, the labour will not be lost.

Whatever be the peculiarities of the climate of Guernsey, it remains to be proved much more clearly than yet has been done, what it is precisely by which the hardiness of plants is regulated, or how it is influenced. It is easy to make use of general terms, but they will not satisfy a philosophical mind. The effect of frost can unquestionably be understood in a general way; yet the tender greenhouse plants of England, which are hardy in Guernsey, are not killed by the frosts, in which that island is not wanting, nor by the cold easterly winds, which prevail there with considerable duration and severity. They have always survived those attacks; and sometimes, with the usual shelter from long east winds, have passed through even those very severe winters, so well remembered, in which this island proportionally participated.

Could it serve any purpose, I might here give the meteorological register of Guernsey for a considerable period; but it would not deserve the space it would occupy, as, in truth, very little useful information has yet been derived from the accumulation and parade of those records. To say that the climates of Guernsey and Penzance are very coincident, will be information enough on this head; with this exception however in favour of the latter,

that in all this group of islands, the easterly winds are more frequent, more durable, and I think more severe.

I must therefore leave this question of the cause of the beneficial influence of this peculiar climate as to the plants which it encourages, to future inquiry and other hands ; yet not without remarking that this is not a very sunny climate, either as to light or heat. I believe that in a great many matters appertaining to vegetation, whether in horticulture or agriculture, the question of light is often of much more importance than that of heat, however much it has been overlooked by agricultural as well as philosophical writers. It is of most material importance as to the perfection of flowers, whether in vigour, colour, or odour ; and not less so, as is very well known, as to the ripening of fruits. Nor does it appear to me less so as to ordinary agriculture, whether as it relates to the perfection of certain herbaceous plants, or the ripening of grain. I think this is peculiarly visible in certain parts of Scotland, where the most serious differences in this respect occur ; where no other circumstance of difference than that of the annual quantity of light can be discovered, and when indeed the condition as to temperature, and soil both, is highly in favour of those climates where the produce is worst. This is remarkably true in comparing the eastern and western sides of Scotland generally, and in noting the singular limitation of the region of wheat thus produced ; and, unless I mistake, a difference in the vigour, and especially in the vigour of flowering, in clover, not to be accounted for by differences in the soil, method of cultivation, or quantity of manure. And while the power of producing wheat, or what, for the present purpose, is analogous in principle, the early ripening, as well as the superior quality of barley, diminishes in proceeding westward on a parallel of latitude, till we arrive at the cloudy region, it reappears on passing this again to the westward ; insomuch, indeed, that much more northern latitudes, if the lands are insular and flat, are superior in these respects to the southern ones, while there are no differences as to soil, cultivation, or aught else, capable of explaining the facts. It is not a difference in rain

merely, nor is it a difference in the mean or the summer temperature; since it would be abundantly easy to produce geographical proofs of this, could I here enter on a subject of such detail. Nor is there any solution to be given but that of the differences of light: an explanation indeed which ought not to be questioned, since the effects of this in ordinary horticulture, as to fruits, are acknowledged, whether for benefit or injury, as it shall exceed or fall off. That a register of light ought to form an essential ground of judgment on agricultural questions, relating to territorial or geographical position, is a conclusion naturally following from this view.

The deficiency of light in Guernsey is not such as to interfere with its flowers, as the season of flowers is its purest summer: but the want is decidedly marked in autumn, and especially in respect to the difficulty of ripening grapes out of doors, in which it is inferior to the English central counties, which produce grapes in this manner. It is usual to attribute this to defect of heat; but the heat of Guernsey, by the register is, at that late period, equal to the heat of the English counties in question, though the cloudy atmosphere renders the light inferior. And if the effect of greenhouses does, as is unquestionable, depend, in a great measure, on the heat which they concentrate, it is not to be forgotten that one of these effects is to bring forward the fruit, so that its period of maturity shall approach nearer to that season in which light is most abundant. This conclusion is indeed amply confirmed by the effect of cloudy summers, even on the grapes of the greenhouse.

Thus much it was necessary to say respecting this climate, as concerned with the peculiar appearances of its horticulture, and I must proceed to describe the few facts, as to individual plants, which may be in any way interesting. One of the objects is here to show, that certain plants of hot climates differ materially in hardiness from others, as a temptation to try more widely the extent of this law. Another is, to demonstrate the injury which many plants, perhaps all, receive from confinement, as an inducement to further trials on plants which have hitherto disappointed

us by their unwilling growth. And, in addition, I should wish to prove, if indeed it can be proved, that a process of naturalization can really be carried on by sowing native seeds ; or at least, that this is so far true respecting certain plants, though it may not be a general law, as to render a continuation of the same experiments advisable. Any other miscellaneous remarks that may arise, must defend themselves on the claims of their utility.

On the question of naturalization by sowing, I formerly remarked, that the Canna indica had here become an absolute weed, propagating itself perpetually. One of two useful conclusions follows. It has either been naturalized by this process, as the Zizania is supposed to have been, or else this West Indian plant, a native of a hot and moist region, was originally a hardy plant for this climate. If this last only be the conclusion, it is a temptation to try an endless number of other annuals or biennials, or of plants generally, whose roots remain in the ground to spring up afresh in summer. It is possible that the successful list may prove a long and a valuable one.

Supposing this to be the real fact as to the Canna, it is confirmed by another plant, which proved to be hardy in Guernsey, and sprung at once in the open air from imported seeds, producing also its own seeds. This is a species of Panicum, the Guinea grass. We might indeed expect hardiness in this tribe, if in any, from our general knowledge of their peculiarities, and from the wide geography, artificial in so many cases, of the common Cerealia. Should this prove true, even our agriculture might gain widely by the introduction of many of the grasses of hot climates : a result that might often be profitable, even when the seeding was uncertain, in the case of these being durable, or perennial, or propagating by roots. It would be singular if this Panicum should be the only hardy grass of a hot climate.

This capriciousness, as to hardiness, is also evinced by the Pine-apple, which, it is now known, can be cultivated and ripened without fire ; although, from the usual obstinacy shewn as to all improvements, the practice has not spread. The fruit thus grown in Guernsey, and probably elsewhere, is fully equal in bulk and

flavour to that produced by fire: it had even struck me that the flavour was superior; but, as must be expected, it is not produced so early in the summer as under the forcing frame.

I might here, under this head, and for the same purpose, produce other examples; but they are unnecessary in proof of the fact itself, which is even thus sufficiently established as an inducement to more extensive trials. I may now quote another plant, which seems to aid in confirming the opinion, that a seedling from native seeds is really more hardy than the imported parent, or than its portions propagated in the usual methods of slipping or laying; or that there is a certain power thus possessed over the naturalization of plants.

This is the Psidium Catleianum. In Guernsey, or elsewhere, there were plants of this shrub produced by this process, and which yet never bore fruit; which even now, after many years, and in the very same houses, have not produced any, while the seedlings from the English seeds are annually covered with a profusion of ripe fruit, the plants becoming fruitful after the second year. The seed in question was produced by the Horticultural Society; and its generations, as far as they have gone, are all equally fruitful, while the original slips remain as barren as at first. This then seems a fair case of naturalization, and appears to confirm the conclusions formerly drawn as to the Canna indica and the Zizania. Whatever others may be conceived to bear on this point, will be found in the appended list; but I am unwilling to place them here in confirmation, while any doubt remains, that I may not appear to prejudge the question.

The last question of a general nature here noticed, is that which relates to the advantages gained by removing plants from the greenhouse to the open air. It has happened to a great number in Guernsey, some of which will be found in the appended list, that after many years of care, and following the usual fashion, the growth continued stunted, or the plants even threatened to die; many of them actually dying, and no possibility of producing a seed having occurred. From weariness rather than system, these were turned out to their fates, and the consequence was immediate

vigour, and a liberal and constant production of fruit or ripe seeds; while the plants have now become the common tenants of the borders or shrubberies. This then is a fact, which though well known to many English gardeners as to certain plants, has not been acted on so widely as it might, and which deserves a more extended trial, however difficult it may be to explain what is the peculiar suffering which plants undergo from the confinement of the greenhouse. If many points, as to the effects of stoves and houses, are explained, whether as to heat, moist air, as in the case of West India plants in particular, and shelter from winds, there are others, both for good and evil, which yet stand in need of examination; nor will these investigations be successful till we shall become much better acquainted with the physiology, I might almost say the metaphysics, of plants than we yet are. I need not here say to whom we are indebted for much valuable knowledge on this subject, since a record like this could add nothing to his reputation; but it may fairly be said, that while the botanists assume the exclusive honours of science to themselves, it is to the horticulturists, too often affectedly contemned, that our greater debts are due on more points than that of mere utility; that utility which system and nomenclature pretend to undervalue. In the case in question, for example, it remains, among other things, to explain why it is by cramping the roots of one plant that it is induced to produce fruit; while, in another, the same effect is attained by giving to the roots the full liberty of the surrounding soil.

But these are subjects not within the present inquiry; and as to the following list, I shall only remark, that in as far as any plant may be found in it which is equally hardy about London, for example, as in this island, I must apologize for the ignorance, by saying that this list was collected when horticulture was far other than it is now in England, and that many years of interruption have prevented me from keeping my own knowledge of this subject at the level of the surrounding experience.

I cannot however draw up this document, without noticing the extreme vigour and beauty of almost all the flowering plants in this favoured climate, favoured at least in this respect; a vigour

which seems to show that the heat of a climate is not its most essential part, as the upward range of the thermometer in this island is very narrow compared to England; seldom or never equalling it, at the extreme, by ten degrees. The term mildness is sufficiently unmeaning as a solution of the difficulty; and I know of no advantage to be derived from indefinite language. One fact however does deserve notice, and that is, the soil; which is, for want of more definite terms, a yellow loam, deep, and produced by the decomposition of gneiss. This is perhaps one of the most extensively advantageous soils for the cultivation of flowers; while it is certain that many gardeners are still in error on this subject, in preferring dark agricultural soils for that purpose. But I must pass on, lest I should trespass on my narrow limits; yet not without an example or two of this singular vigour and beauty in the common flowering plants and shrubs.

This is very remarkable in the Verbena triphylla, among others, assuming the size of a small tree; and not less so in the Hydrangea, which grows to an enormous bush, and is covered with flowers during a very long season. It will convey a more accurate idea of this vigour, to say that there were cut, in one case, from one plant, at the same time, a thousand and fifty-four flowers, and each of them of a very large size. In general also the flowers are blue, and of an intensity and splendour of colour which never occurs in England; while among the other mysteries which attend the production of this particular colour in this strange plant, it is observed that those which produce pink flowers on the low grounds, or near the sea, are invariably blue in the higher lands, although the soil is the same. That the sweet, as well as the bitter orange, are annually covered with large crops of ripe fruit out of doors, are proofs that this mysterious mildness, whatever it is, is of more importance than a very hot or a very sunny climate.

Yet it is worth remarking here, that vigour of growth or splendour of colour are circumstances depending on different causes from that vigour of action in other respects, which it requires a hotter, and perhaps also a more luminous climate, to bring forth: and the fact, as relating to vegetable physiology, may perhaps

hereafter be of some moment when this subject shall be better understood. At so small a distance as that of the neighbouring shore of France, the same plants, in the same summer, possess an odour, which, if odours could be measured, might be pronounced twenty or fifty times greater than in Guernsey. In a certain sense, this can be decided on; inasmuch as the smell of the common jasmine in that part of France can scarcely be endured, from its power, while a single flower appears to possess more of the quantity or matter of odour, than a hundred grown in Guernsey, as well as in England. And it is the same as to the Rose and others; proving, as it would seem, that, as to this result, light and heat are more essential than in the case of general vigour, or even colour. The broad fact, as to the flowers of the south of France and Italy, is sufficiently familiar; and hence the comparative futility of the attempts to extract perfume from most English flowers, and the infinite superiority of those made about Hyeres and Frejus.

I have not thought it worth while, in the following list, to distinguish the plants exclusively hardy in Guernsey, from those which have also recently been rendered so in England; because those acquainted with our present horticulture can readily distinguish them. Some of them are introduced, not because of this, but for the sake of their peculiar vigour or other circumstances, as I know very well that they are, as far as mere hardiness goes, hardy also with ourselves; while where others, equally hardy with us, are here named, it is because they are common weeds, even in the gardens of the cottagers, when, with us, though hardy, they are still considered somewhat delicate, or are rare out of doors.

The Physalis alkekengi, the Solanum pseudo capsicum, and most others of the genus generally found in our gardens, are hardy, even to neglect. The Peonia arborea is as much so as the common peony; and the Yucca aloifolia, somewhat rare in our gardens, is there common, and covered with a constant profusion of flowers, growing also to a very large stature. I need scarcely perhaps say that the Laurus nobilis is as hardy as the myrtle;

since it is equally so where the myrtle is hardy in England. In Guernsey the three common species of myrtle seem to be equally hardy; though the cross-leaved one is less ready in flowering than the other two. The Fuchsia, like the Verbena triphylla, is remarkable for the extraordinary vigour of its growth; and if there is no period of the year in which the China rose does not flower, it is an example of that mildness in the winter, to which, possibly, so much of the general success may be owing. Thus, the Erica mediterranea becomes a large tree; while the baccans, and a few more, kept in our greenhouses, grow also to a great size, and are the ornaments of the shrubbery.

Among the tenderer Hypericums, the crispum, the ericæfolium, and a broad-leaved one common in our greenhouses, whose specific name has escaped me, are perfectly hardy; as is the Veronica decussata, the Thea viridis, the Correa speciosa and alba, and all the Melaleucas which we cultivate. The Magnolias, including the grandiflora, tetraptera, glauca (of course,) conspicua, purpurea, and others, are here remarkable for the vigour of their growth and the profusion of their flowers; far excelling, at least in the more refractory ones, the plants of our own shrubberies; while the Dahlia, now so common, is almost a nuisance, from the enormous bulk and stature of the bushes which it forms.

Thus the Camellia japonica does not only produce large shrubs out of doors, attaining to the height of twenty feet, but is covered with flowers, double as well as single, white and red, even to contempt; as the Leptospermums, including the lanigerum, pubescens, myrtifolium, acutifolium, and another whose specific name I have forgotten, are almost trees, in the shrubberies where they are cultivated; accompanied by every Diosma which we possess, attaining a similarly powerful growth, compared to those of the greenhouses. I ought formerly to have remarked that the lemon grows together with the orange, protected only by a wall from the violence of the west winds; and when I named the Verbena, I might have said that I had measured the stems twenty inches and more in circumference, with an altitude and spread of twenty feet and upwards.

The Mimosa paradoxa is also a powerful shrub; sowing its own seeds annually, and possessing a profusion of flowers, which renders it one of the greatest ornaments of the shrubbery; while it is here remarkable, as proving one of the general facts already stated, that, in no instance, could this plant be induced to produce its seeds in the greenhouse. That all the shrubby natives of New South Wales known to us will probably prove hardy, here at least, and improve accordingly in vigour, there is no reason to doubt. Many other Mimosas, formerly treated as tender, are equally found hardy, and equally to improve under exclusion. I may add an Argophyllum to this number; together with three Sophoras, the tetraptera being common with ourselves; the double as well as the single Nerium oleander, growing to almost a tree in the shrubbery, a number of Proteas, the Jasminum azoricum and odoratum, the common olive, producing fruit, with some other species of Olea, the Cistus, in many species, which with us are confined to the greenhouse, the Clethra arborea, the Daphne odorata, and others, of various degrees of reputed tenderness, which might swell this part of the list to too great a length. But I may still add the Bignonia capreolata and Pandora, on account of their vigour and beauty, two Punicas, the Hibbertia volubilis, and a Metrosideros, of which I have here missed the specific name, the Colutea coccinea, sowing itself annually, the Celtis micrantha, and the common Heliotrope; chiefly, because they include, with some of the former, examples of the great accession of strength which the confined plants gain by being turned loose to nature, and partly because of some of them thus producing seeds with freedom, even from the very same plant, when they had refused to do so in confinement. The Heliotrope now not only sows its own seeds in the open ground, but produces plants of uncommon strength and luxuriance; but whether this is a process of naturalization or not, is a question which, after the doubt already recorded, I feel no inclination to ask.

If I have passed over some of the shrubby plants that I might have noticed, such as the Gnidia pinifolia, odorata, simplex, and many others, it is of no moment, as the list is long enough for

the intended purpose; and if it shall be objected that some are already hardy in England, it must be remembered that part of the object was to show the great increase of vigour gained by exclusion and climate together, as in the case, for example, of the Veronica decussata, which grows about the little gardens of the cottagers, to the size and appearance of a common gooseberry-bush.

As to the effect of exclusion, and in a sort of herbaceous plant, if I named the Yucca before, I might have remarked that the filamentosa and the aloides are equally vigorous, and that, on the first plant of the tenderer of these species the effect of exclusion was to cause it to flower in the first year, after having been many years in the greenhouse without showing the least inclination to blossom. If the American aloe does not choose to flower very often, it does nevertheless flower out of doors, and propagates itself with great vigour, even in stone walls.

Among herbaceous plants reputed tender in various degrees, but here flowering vigorously and freely out of doors, I may enumerate the following, without any anxiety to distinguish such as have been occasionally treated as hardy by gardeners in England. Like the shrubs already enumerated, they may lead to further trials among ourselves.

Every Mesembryanthemum, without exception, having been found hardy, I need not name the species: and the same has been found true of a great number of the Cactus, of which, however, I need only name the hexangularis, the formosissima, the common caterpillar, and the prickly pear. Of allied plants, the Crassula coccinea has also proved hardy. An Echium sent from a London hothouse, whose specific name I could not at the moment discover, and long kept in the house, proved perfectly hardy: offering one proof, among a thousand others that might be adduced, of the mistakes committed on this subject, which have so long contributed to rob us of ornaments that ought to have been now flourishing in our gardens. This, in fact, is a leading error among all gardeners. Regulated merely by habit, or else by geography as to new plants, it is not sufficiently often inquired

what the real climate of the plant is, since this is a fact not always regulated by the geography, still less what natural differences, as to physiology or constitution, different plants may possess; even where the climate is absolutely the same for all. That the pine-apple plant should actually pass a Guernsey winter out of doors, is a proof that we have much yet to learn on this subject.

Of the half-tender plants, I must remark here, that the Cobea scandeus, which should have stood in the former list, is quite hardy in this climate; as the Phormium tenax, sufficiently hardy I believe, with ourselves, is so vigorous as to tempt us to try it as an object of economy. The Ipomeas are, similarly, no otherwise remarkable than for their vigour. The common Gnaphaliums of the greenhouse prove also to be perfectly hardy; while the Lobelia cardinalis, hardy with us, is noted, like the Fuchsia and others, for its magnitude and beauty.

I am not aware of the relative tenderness of the several liliaceous and analogous plants which, in Guernsey, are remarkable, not only for their magnitude and the profusion of their flowers, but for their absolute vulgarity; and shall therefore give the catalogue of those which struck me, without a comment. Polhos cordifolia—not exactly in this division—Agapanthus umbellatus, Antholyza spicata, and another whose specific name I forget; Tritonea uvaria, Gladiolus cardinalis, Ferraria undulata, Polyanthes tuberosa, Amaryllis vittata, undulata, formosissima belladonna, and Sarniensis, of course; the latter of which, so long supposed to have arrived from Japan, is at last known to be a native of Buenos Ayres. I should add here, that every one of the Ixias propagates in the ground, without care, so as to become perfect weeds. The Mimulus glutinosus, Gorteria ringens, Dracocephalum canariense, might, with many more, have been added to this list, for various purposes not now worth repeating; but it has already swelled to such a length, that it is time to conclude it. Yet not without adding that while every Geranium has been found hardy, there are singular differences in their apparent relative resistance, and consequent luxuriance, even where they are, as far as we know, all natives of the same exact spot and climate.

Thus I may terminate this subject as it regards Guernsey, and the conclusions which may be drawn from the peculiar character of its vegetation. But on the probable or possible subject of naturalization, it must yet be added, that the experiments on seedling vines seem also to prove that such an effect does really take place; as, in many instances, the fruit of those has been found to ripen with greater facility and certainty than that of the ordinary plants from cuttings. The whole question must, however, remain for further examination. Did it only concern this question,—the increased facility of producing grapes out of doors,—it would be amply deserving of much fuller trials than have yet been made; while, when it is recollected how much it interests the far more important question of the potatoe, particularly as this relates to its cultivation in the wretched climates of Scotland, there is nothing in the whole range of horticulture that is more truly deserving of a serious course of experiments; a course which should be indeed undertaken as to many other plants before we reject the belief altogether.

It is certain, as a general principle, that different plants vary very much as to their sensibility respecting cold; even when we can discover no reasons in their constitution, their structure, or their general physiology, why it should be so; and, similarly, where these natural affinities, or family connexions, and not less their native climates, afford no ground for any *priori* judgment as to this. The examples would be as endless to quote as they are familiar. Is this a case, sometimes, of mere sensibility, of the action on a nervous power, if I may use such a term, a power of which the existence seems proved by their sufferings from various poisons? And if so, is it possible to change that constitution, as it appears to be susceptible of being changed in animals—by habit? In animals, the organization remains the same, but the sensibility is diminished, while probably, possibly, the heat-generating power is augmented. Here perhaps one difficulty may lie, as it certainly does, in the extreme case, as to vegetables. It is more than doubtful whether they do generate heat; and if this were necessary, we should be disappointed. But if not, and if the effect be an effect on their sensibility or nervous system, and

if this can, within certain limits, be diminished by habit, as in animals, naturalization within these limits, is not impossible.

If this be plausible, the road is obvious, for vegetables as for animals; it is gradation of climate and a succession of generations. Thus it has been widely effected for animals, and thus it may perhaps be effected for vegetables; if less widely, from the want of powers productive of heat to resist the excess of a new and destructive influence. Let us not decide on this impossibility *à priori;* not, philosophically, till we are better acquainted with vegetable physiology, and, in no case, till we have conducted a much wider series of experiments than the few controvertible ones already made.

There is a plausibility respecting this view of the sensibilities of plants. The Nasturtium, in the full vigour of flower and fruit, is killed in an instant by frost, vigorous to the very moment of freezing. Our own herbaceous plants, of structures as similar as the eye can ascertain, go on resisting, many of them, throughout a severe winter. The difference is not in the vessels, in the circulating system, in the fluids. In both they would equally be frozen; but, to one, this condition is death, while the other heeds it not. Where then is the difference, if there be not a nervous system? that system the seat of life, the system whose action is destroyed by poisons, destroyed even by the narcotic poisons. Plants are poisoned as animals are; not by an action on their fluids, not under a system of humoral pathology (to use old medical language), since their primary circulating fluid is water, not to be decomposed by the poisons which kill them; as the blood of animals might be, and has been, supposed to suffer. But I must reserve this subject for another occasion. It is sufficient to have thrown it out as a hint on this particular question; and should it prove a fact, as it cannot fail to prove, should the various sensibilities of plants prove analogous to those of animals, we shall be enabled to explain many more phenomena than the tenderness of the Caper, the affections of plants for peculiar situations, climates, elevations, what not, phenomena which have long been a stumbling-block in the way of botanical philosophy.

Art. III.—*Descriptive Arrangement of Volcanic Rocks.* By G. Poulett Scrope, Esq., M.G.S.

[Communicated by the Author.]

In the course of a series of investigations of the geology of volcanic districts, the writer of this paper has met with great inconvenience from the want of a fixed nomenclature and mineralogical classification of this family of rocks.

MM. Cordier and Fleurian de Bellevue, in two well-known memoirs *, proposed a systematic arrangement of volcanic rocks on mineralogical principles; which, however, has not as yet got into general use, owing perhaps to some obvious imperfections in the mode of arrangement.

M. D'Aubuisson followed these writers in classing the pyrogenous rocks into two main families, trachyte and basalt; according to the prevalence of felspar or augite in their composition, and these terms have since been generally adopted on the continent.

But of late great confusion has been introduced into the subject by the determination of M. de Beudant †, and after him of M. de Humboldt ‡, to confine the terms Trachyte and Basalt to rocks of a particular age and position in the geological series. This attempt has originated in an unfortunate mistake of these distinguished geologists, who have been led by their observations to presume, that rocks of the mineral character of trachyte never occur superposed to their own conglomerates, or to tertiary strata. That this notion is false in fact, may be proved by numerous examples from the Mont Dor, Cantal, and Italy. But, had it been true, still it is by no means allowable to employ the mineralogical title of a rock to designate its place in a geological series. This is the more strange in the latter author, because he talks of granites of different ages, of syenites and porphyries of

* Cordier. Essai sur les Roches Pyrogenes de tous les Ages.—*Journal de Physique.* Fleurian de Bellevue.—*Journal de Physique,* tom. lxxxiv.

† Beudant. *Hongrie,* tom. iii.

‡ Humboldt. *Essai Geologique.*

primitive and transition formations, *&c.*; and because he ever expresses himself in these positive words, "There are trachytes, phonolites, basalts, obsidians, and perlites, of *different ages*, just as there are different formations of granite, gneiss, mica-schist, limestone, grey-wacke, syenite, and porphyry." How then, after this, could the same author confine the term trachyte, basalt, and phonolite, to rocks of a particular epoch, and vaguely unite all the rocks mineralogically identical with them, but bearing appearances of a later date, under the undescriptive, undistinctive term "Lavas." How much more simple, after such a confession of the different ages of the same rocks, to name them geologically by means of epithets superadded to their primary mineralogical designation, in the same manner as the other rocks are treated. We should then have secondary trachytes, tertiary trachytes; or, if it was preferred, trachytes of the new red sandstone, trachytes of the greensand, recent trachytes, *&c.*

It is so obvious that the determination of the mineral characters of a rock must precede any attempt to find its place in a geological system, since it is *only* by these characters that it can be distinguished from the other rocks with which it is associated, that it is difficult to believe any person would dispute the propriety, not to say the necessity, of a mineralogical nomenclature being made use of for the *primary* terms of a geological classification. In fact, such a classification is a Tabular History of Rocks, or of the globe's surface, and requires a great deal of previous description and comparison of all these rocks according to their mineral nature. It is also founded on hypothetical views, since it is a mere hypothesis, and perhaps a false one, more particularly with respect to the elevated strata, and, above all, the unstratified rocks, that *superposition* is any proof of a posterior origin. The arrangement of rocks on such a basis must necessarily be dubious, insecure, and often erroneous. Whereas no error can be committed in a nomenclature which is merely descriptive, and founded on oryctognostical principles. The character inferred by the name must always be true of the rock to which it has been applied; all speculative ideas as to age or origin

are kept out of view; at the same time that this arrangement displays the various rocks known in a clear, concise, and ready manner, for the purpose of any ulterior classification upon geognostical or geological principles that may be preferred *.

These considerations will perhaps evince the propriety and utility of generally adopting some such descriptive nomenclature for all classes of rocks, as that which is here proposed for those of unquestionable volcanic origin, or the *pyrogenous rocks*. The end which the writer has had in view is to offer concise and comprehensive definitions of the principal oryctognostical characters of this family of rocks, by the use of which any one of its members may be distinctly described by an observer in a manner intelligible to all geologists.

The *primary* characters by which alone the nature of a rock or mineral mass, simple or compound, can be identified, are those of its mineral composition, texture, the relative disposition of the component minerals, if a compound rock, its internal structure, and natural divisions.

The colour, lustre, fracture, hardness, fusibility, and specific gravity of rocks are obviously determined by their qualities of mineral composition or texture, and must vary with them; these

* The utter absurdity of making the primary or only name of a rock indicative, not of its mineral nature, but its geological connexions, is instantly seen, by supposing that this principle were acted on, not in one or two, but in all cases; the consequence of which would be, that we should have no names whatever; for to say that granite is a rock determined by its underlying gneiss; gneiss characterized by its underlying mica-schist, and this by its bearing the same relation to clayslate; and so on, would be to pursue the most vicious of all circles, since we can have no means of distinguishing an over from an underlying rock, but by their distinctions of mineral character: these must therefore be determined, and the mineralogical characteristics of each rock defined (which cannot be done without applying some name to it), *before* their relations of position can become a question. To force the *primary* name of a rock to denote its supposed place in a geological series, would be as inconvenient and irrational as to confine the name of a simple mineral to one found in a particular locality, so that, when met with in another, a new name must be invented for it; or to give, for instance, the name of felspar to this mineral only when in company with mica, and refuse it the appellation when associated with quartz. Hence arises a *general rule*, that when a rock possesses but *one name*, it is significative of its mineralogical character.

therefore are secondary characters, not characteristics. Of the primary qualities, that of mineral composition is obviously by far the most important towards identifying the rock. All the other characteristics are probably accidental modifications determined by the mineral composition, under the influence of external circumstances; whereas it is difficult to conceive this latter character to be in any way influenced by the others, under any circumstances.

Hence the *mineral composition* of the rocks under review at present has been taken as the basis of their systematic arrangement into genera and species; the sub-species and varieties being distinguished, according to the remaining primary characters, under the separate heads of—

1. Texture.
2. Mineral disposition.
3. Internal structure.
4. Natural division.

There is, however, one previous distinction which it is incumbent to draw between the rocks of the trap family, and which is rather of a geological than mineralogical nature; *viz.*, their division into the two *classes* of *lithoidal* or *massive*, and *fragmentary* rocks; according as they are composed of minerals intimately united by the force of crystalline aggregation; or merely of separate parcels of matter, incoherent, or enveloped in a cement, whether crystalline or earthy, but evidently of later origin than the fragmented portions it encloses.

The second step is to arrange the lithoidal rocks into genera, according to their broad general characters of mineral constitution. Now it has been ascertained that all the rocks of this family, with very few exceptions, are principally composed of felspar and augite in varying proportions. The felspar is sometimes partially or wholly replaced by leucite, melilite, olivin, or haüyne; and this substitution is observed only to occur when the proportion of augite in the rock is very considerable. The augite appears in the same manner, occasionally replaced to a greater or less extent by mica; and this occurs only when the felspar is greatly in excess. The augite is either pyroxene or hornblende, the one seeming to replace the other in proportion to the abund-

ance of felspar. Titaniferous iron and sphene are subordinate but very general ingredients in these rocks; the former is often in considerable quantity, and abounds most in the augitic species. Quartz occurs very rarely in crystals or grains; garnet, spinelle, sapphire, and other still rarer minerals can only be reckoned as accidents.

It is seen then that these rocks naturally group themselves into two principal orders; *viz.*,—1. That in which felspar predominates exceedingly. 2. That in which augite or the ferruginous minerals are in excess; or at least so abundant as to stamp their character on the rock. This is, in fact, the division which has been generally made by the continental geologists, who have called the former order *trachyte*, the latter *basalt*.

But the shades of mineral composition amongst the compound rocks of this family are so varied in nature, and graduate so imperceptibly into one another, that two genera alone can hardly be reckoned sufficient.

A very numerous tribe of rocks is to be met with, in which the proportions of felspar and augite are such, that it is impossible to tell which predominates, while, in their general characters, the rocks are so unlike the extremes of either genus, that it is scarcely allowable to rank them together. It appears from these reasons expedient to institute an intermediate class of rocks, for the reception of those members which cannot, without difficulty, be referred to either of the two extremes. The name which I conceive most appropriate to them, as having been applied to such rocks already by Werner and other mineralogists, and as susceptible of little misconception, is greystone (graustein), their colour being universally of some tint of grey, generally lead-grey, greenish, iron, purplish, or slate-grey, with the exception only of their vitrified varieties, some of which have assumed a black colour, which, however, passes away under the blowpipe, and is succeeded by the usual grey tint *.

* Greystone corresponds in part to the class of volcanic rocks called tephrine, by M. de la Metherie. It comprehends also the majority of clinkstones.

The genera of the volcanic, or trap family of rocks, will then consist of—

I. Trachyte.
II. Greystone.
III. Basalt.

It may, perhaps, be objected to the basis of this arrangement, that these substances frequently appear homogeneous, and hence their constituent minerals are undiscoverable. This is, however, far from the case. There are very few rocks of this family, indeed, in which a good lens, or at furthest, a microscope, will not discover a granitoidal mixture of the constituent minerals in a crystalline form. The method of mechanical analysis, first proposed by M. Cordier, will determine this with accuracy and certainty. But, for ordinary purposes, examination with a lens will be sufficient, and even the colour may be generally depended on as an accurate criterion, unless the rock is passing to a resinous or vitreous state, under which circumstances the lightest-coloured felspar rocks sometimes assume a blackish hue *.

Speaking generally, the colour of the mass is deeper in proportion to the quantity of augitic matter in its composition, the felspar being always of a light colour, the augite a darkish-green or black, and the iron a dark-brown or black. The proportion of felspar, or its substitutes, which exists in trachyte, may be reckoned at, or above, 90 per cent., the remainder being composed of augite, or the ferruginous minerals. In greystone, felspar or its substitutes composes more than 75 per cent.; when these minerals are in less proportion than 75 per cent. the rock should be classed as basalt.

Another auxiliary test, in which greater confidence may be reposed, is the specific gravity of the substance when reduced to powder. In fact, the specific gravity of the augitic and ferruginous minerals is so greatly superior to that of felspar, that an

* Apparently derived from the bitumen, which appears, from chemical analysis, to be present in this condition of the rock, and which is volatilized on exposure to the blowpipe.

observation of this nature will indicate the general proportion of these two classes of minerals in any volcanic rock. In general, the specific gravity of trachyte will be found not to exceed 2.7, that of greystone 3.0, while basalt occasionally reaches 3.50, which is much above the specific gravity of augite alone, and caused by the presence of a quantity of iron in a metallic state.

A third test consists in the colour of the glass, produced by fusion of the mineral before the blowpipe. That resulting from trachyte is light-coloured, and nearly transparent. The glass of greystone is darker, and spotted with numerous green or black specks, often of a green colour, bearing a constant ratio to the proportion of ferruginous minerals in the rock. Basalt melts into a dark green, or black enamel. Observations which have been often made on these rocks, and which, without being insisted on as infallible criteria, will yet often assist in distinguishing them, are—

1. That leucite has not been found to occur in any trachyte, only making its appearance when the proportion of the heavier minerals is considerable; rarely in greystone, oftener in basalt.

2. Olivin never has been met with as yet but in basalt; it appears to replace the felspar, in part or altogether, only when augite is in excess.

The specific divisions of these genera should be drawn from minor modifications of mineral constitution: a tabular view of the principal species is subjoined.

Genus I.—Trachyte, characterized as above.

Species A. Compound trachyte with mica, hornblende, or augite, sometimes both, and grains of titaniferous iron.

" B. Simple T., without any visible ingredient but felspar.

" C. Quartziferous T., when containing numerous crystals of quartz.

" D. Siliceous T., when there appears to have been introduced a great deal of silex into its composition.

Genus II.—Greystone.

Species A. Common greystone, consisting of felspar, augite, or hornblende and iron.

" B. Leucitic greystone, when leucite supplants the felspar.

" C. Melilitic greystone, when melilite is substituted for that mineral, *&c.*

Genus III.—Basalt, characters as above.

" A. Common basalt, composed of felspar, augite, and iron.

" B. Leucitic B., when leucite replaces the felspar.

" C. Basalt, with olivin in lieu of felspar.

" D. Basalt, with haüyne in lieu of felspar.

" E. Ferruginous basalt, when iron is the predominant ingredient.

" F. Augitic basalt, when pyroxene or hornblende compose nearly the whole of the rock.

The character which ranks next in importance, towards the descriptive qualification of a volcanic rock, is its *texture*, and by this character the subspecies may be, with propriety, distinguished.

All lithoidal volcanic rocks, with the exception only of those which have partly, or wholly, passed by complete fusion into the state of glass, consist of an aggregation of more or less imperfect crystals of one or more minerals.

The average size of these crystals, or integrant particles, determines the *grain* of the rock, which is one of the elements of its texture. When the average size of the crystals is so large as to strike the eye by its crystalline structure at a distance, as in granites, the texture is called *granitic;* when of such size as to be discerned only by close inspection, *granular;* and when so minute as to require a lens to ascertain its crystalline texture, or the assistance of the mechanical analysis, *compact.* When the rock appears to be passing to the state of a glass or enamel, assuming a pearly, waxy, or resinous lustre, its texture is called

resinous, or *semi-vitreous;* and lastly, the finest texture of all is the *vitreous*, or *glassy*.

But, besides the size of the crystalline particles, another character influences the *texture* of the rock, *viz.*, their more or less intimate aggregation, which may be *loose* and incoherent, giving an *earthy* aspect to the rock ; or *close* and compact, producing the effect of *hardness* and solidity. Another and still more important characteristic is, the regular or irregular *disposition* of its component crystalline particles, which are sometimes aggregated in a confused and disorderly manner, without any determined method, so as to give an irregular fracture to the rock, as in granite, claystone, *&c.*; at others, they are arranged so that their longest plane surfaces preserve a more or less perfect parallelism to one another, through a considerable space, by which a *foliated*, or *scaly* texture is given to the rock, and a splintery or slaty fracture, as well as a lamellar or schistose structure, on a large scale. This remarkable difference in the disposition of the crystalline particles is always found to pervade the whole mass of rock, and, in fact, forms the only distinction between granite and gneiss, claystone and clinkstone.

Hence, according to the arrangement proposed here, the subspecies of the volcanic rocks should be distinguished by epithets significative of their peculiar texture, *viz.*,

A. Granitic		
B. Granular		
C. Compact	*a* Massive, or granitoidal	Loose *α*.
D. Resinous	*b* Scaly, or foliated.	Close *β*.
E. Vitreous		

The texture is also either, 1. *Uniform*, which needs no explanation, or, 2. *Varied*, when consisting of parts of different texture. Epithets may be also made use of to describe the general form and disposition of these parts, as, 1. Nodular. 2. Lenticular. 3. Zoned. 4. Brecciated.

These varieties of texture in the same mass are generally connected with, and in all probability owing to, an unequal distribution of the different minerals composing the substance, which forms

another very characteristic distinction amongst this family of rocks, and may with propriety be assumed as the basis of their division into *varieties*. The principal modes of mineral distribution are—

1. *Uniform*, when the minerals are generally intermixed throughout the mass, as in granites, syenites, *&c.*

2. *Porphyritic*, when large crystals, or grains, of one or more minerals are dispersed throughout a base of very fine texture, and uniform disposition, so as to strike the eye by their prominence, as in porphyries.

3. *Globular concretionary*, when some minerals have more or less completely separated themselves from the remaining mixture, and agglomerated into globular nuclei, as in pearlstone, variolite, orbicular granite, *&c.*

4. *Nodular concretionary*, when some minerals have separated in the form of irregular knots, as in the masegna of the Euganean hills, in many granites, and porphyries, or like the flints in chalk.

5. *Lenticular concrotionary*, when the figure of the segregated parts is much elongated in any one direction.

6. *Zoned concretionary*, when they are elongated still more into alternate stripes.

7. *Veined*, when one or more species of minerals appear to have occupied cracks in the rock.

8. *Amygdaloidal*, when one or more minerals have occupied vesicular cells in it.

The next head under which it has been thought right to class the characteristic qualities of these rocks, is their *internal structure*, which comprehends the following varieties :—

1. Massive, or compact.

2. Porous, as are all loose-textured, earthy, and bibulous rocks.

3. Cellular, when the cavities are visible to the eye, but irregular and angular.

4. Vesicular, when the cells are more or less spheroidal.

5. Cavernous, when the blisters or air-cells are of a very large size, and very numerous.

6. Spumous, when the air-cells are so numerous as to give a

lightness and frothy appearance to the rock, as in some varieties of pumice and scoria.

7. Filamentous, when composed of twisted thread-like fibres.

The last head to be noticed in the description of this class of rocks is their *divisionary structure;* by which is meant the figures of the parts into which the rock is divided by seams or natural clefts. Frequently there are no such separations of continuity, and the rock is then pronounced *amorphous*. The varieties of divisionary structure may be classed as—

1. The bedded structure, when divided into massive beds.
2. Stratified, when the beds are less bulky, from the greater frequency of the seams.
3. Tabular, when the separate divisions are still thinner, flat, and of no great longitudinal extent.
4. Laminar, when still thinner.
5. Schistose, lamellar, or slaty; a well-known structure.
6. Columnar, when the divisions are regular many-sided prisms of considerable length.
7. Prismatic, when the form of the prisms is less regular, and the transverse joints more frequent.
8. Rhomboidal, when there exists a double system of parallel seams, dividing the mass into portions approaching in figure to cubes or rhomboids.
9. Conchoido-prismatic, when the boundaries of these portions are curvilinear.
10. The *globiform*, when the rock is divided into globular masses of a large size. These are often subdivided into concentric laminæ, less frequently into radiating prisms, or even columns.
11. The globular, when the spherical concretions are very small.
12. The angulo-globular, when the rock separates into small angular divisions rudely approaching to a globular form. It resembles the conchoido-prismatic structure on a very small scale.

The *secondary* characters of these rocks are often of service

towards ascertaining with greater precision their primary qualities, and thus accurately *defining* the rock. They consist chiefly of—

1. The *lustre* and *fracture;* both of which depend upon, and consequently disclose, the *texture* of the rock.

2. *Hardness*, which indicates the mineral composition.

3. *Solidity*, or the coherence of its integrant parts, which depends upon texture.

4. *Fusibility*, which varies somewhat with the size of the grain; the smallest grain melting most readily *cæteris paribus;* but it depends chiefly on the mineral composition of the rock, of which it becomes a serviceable test.

5. *Colour* usually indicates the mineral nature of the rock, unless it is stained by metallic oxides, or other accidental modifications, which are in general easily distinguishable from the genuine tint of the component minerals.

Each of the three genera of lithoidal volcanic rocks possess their conglomerates, which may be referred to any of them, according to the mineral nature of the composing fragments. They thus are divided into—

1. Trachytic conglomerates. 2. Greystone ditto. 3. Basaltic ditto.

The primary characters of these conglomerates, by which they are most distinctly recognised and described, consist of—

1. The average size of the fragments; which may be called,

A. Coarse, when of a considerable size.

B. Gravelly, when of a medium size.

C. Sandy, or arenaceous.

D. Fine.

E. Argillaceous.

F. Mixed, when fragments of one or more sizes are imbedded in a base or cement of finer materials. The cement is occasionally of crystalline texture.

2. The form of the fragments must also be noticed. This is either,

α. angular, β. water-worn, γ. rolled.

3. The fragments should be referred, if possible, to some mineral species of lithoidal rocks, and their varieties, if any, taken notice of; as well as the occurrence of isolated crystals, rare minerals, shells, wood, &c.

4. The solidity of the conglomerate rock; which may be,

A. incoherent, or earthy, B. indurated.

5. The divisionary structure, which is occasionally met with in conglomerate as well as in lithoidal rocks, and is subject to the same varieties of form.

The volcanic rocks, both lithoidal and conglomerate, are sometimes found in an altered state, from having been exposed to the decomposing influence either,

1. Of proximate emanations of aqueous vapours charged with sulphuric and muriatic acids; or,

2. Of the ordinary atmospheric agents.

In the first case the alumine and potass of the felspar and augite are taken up by the sulphuric acid, and deposited by the agency of water, as sulphat of alumine (alumstone), in the cavities and fissures of the rock, and in neighbouring hollows; leaving the remainder of the rock, composed almost solely of silex, in a carious state, but often filled up with other infiltrated matters as well as alum, and stained with ferruginous oxides, from the union of its iron with the oxygen of the acids. In the second case the decomposition of the augite and felspar, sometimes of one, at others of both, produces a variety of argillaceous earths or *boles*, giving to the rock, which is then often called *wacke*, a more or less argillaceous aspect, proportionate to the degree of decomposition, and sufficient to render it occasionally difficult to recognise its original mineral composition. These boles are sometimes conveyed by aqueous infiltrations into the cellular and other cavities of the rock, giving occasion to the amygdaloidal composition.

The object proposed in the foregoing remarks is to endeavour to establish a fixed nomenclature for the principal characteristics of the volcanic rocks, so as to enable any observer to define or describe all their varieties accurately and distinctly, for the ulte-

rior purposes of geology. Names may be subsequently given by geologists to any of these varieties, for the sake of avoiding a redundancy of words, or not, as convenience may dictate. A number of appellations have indeed been given, and confirmed by general use, to particular varieties; some of which it may be as well to specify in this place. Thus the granular, massive, and earthy sub-species of trachyte has been called in England *clay-stone;* in France, *domite; necrolite*, by Brocchi. Compact and close-grained trachyte has received the name of compact felspar, and perhaps of hornstone; the laminar sub-species of the same rock, clinkstone, (phonolite); and this name being appropriated to a peculiarity of texture, is given as well to greystone and basalt, as to trachyte, when possessed of that character.

Resinous trachyte is generally known by the name of pitch-stone; *vitreous* by that of obsidian; and the same when formed into globular concretions, perlite or pearlstone; and the same vitreous basalt has been called gallinace by the French geologists.

Spumous and filamentous trachytes are called *pumice.* Spumous greystone and basalt, *scoria.*

When porphyritic, many of these varieties have been called porphyries; as claystone porphyry, pitchstone porphyry, &c. Large-grained or granitic basalt has the title of *greenstone* (dolerite). Very coarse-grained trachytes have, perhaps, often been described as syenites.

With regard to the conglomerates, the sandy and fine-grained varieties of trachytic conglomerate are generally called tufa, sometimes trass; the coarse and incoherent, lapillo. Those of greystone also usually bear the same appellations. The basaltic conglomerates are occasionally styled peperino, or trap-tuff; but when fine, or sandy and incoherent, puzzolana. Some fine tufas, indurated by water, and, with a lamellar structure, have been made use of and described as tripoli. Basaltic conglomerates, when much decomposed, have been designated by the term wacke, as well as the congenerous lithoidal rock when in a similar condition.

Art. IV.—*On the Barometer.* *By* J. F. Daniell, Esq., F.R.S.

To the Editor *of the Journal of Science*, &c.

London, *May* 31*st*, 1826.

Dear Sir,

In presenting you with another of my *Rejected Addresses*, for insertion in the *Journal of the Royal Institution*, I feel bound, after the late extraordinary occurrences, to preface it with a few words. It has oddly enough happened, that you have been called upon to explain my meaning upon more than one occasion, and have been held accountable for my opinions far beyond the usual responsibility of an editor. Against such proceedings I now earnestly protest, and claim the natural right of being the interpreter of my own words. Should I even be found guilty of high-treason against the autocracy of science, it is far from my wish to implicate you in my offence—

Me, me, adsum qui feci, in me convertite ferrum.

I must be unreasonable enough to request room in your next number for two papers: the first, upon the barometer, was presented to the Royal Society last November; and as seven months have now elapsed, and I have heard nothing of it, I presume it has not even been thought worthy, like its predecessors, of the honour of the archives, or of the usual vote of thanks which is generally given to propitiate the *manes* of entombed communications: I will, however, *guess* that the council have not thought it fit for publication. The second, upon the hygrometer, contains a few remarks upon what they do think fit for publication; in making which I assure you that I have been actuated by no feeling with regard to the proceedings upon the former communication. I have taken some pains to introduce a new instrument into use, the general adoption of which would be considered, by those who are most competent to judge upon the subject, as a great benefit to science; and it is certainly with feelings of regret that I have seen in the last Number of the *Philosophical*

Transactions (in which we know, upon the authority of the president, that nothing is admitted which is not considered sufficiently proved), that the high sanction of the council has been given to an improvement of the hygrometer, which I have shewn is not only no improvement, but a contrivance totally incapable of answering the intended purpose. I regret this, because it is calculated to retard the object which I have so long endeavoured to promote. Those who may be induced upon such high authority to make trial of the improved instrument, and find, as they will do from experience, that it gives deceptive results, will be inclined to suppose that no greater confidence can be placed in the original invention. However, *Magna est veritas, et prævalebit.*

I remain, yours faithfully,

J. F. Daniell.

In a paper upon the barometer, which I had the honour to present to the Royal Society in November, 1824, I submitted to their consideration some experiments and observations, from which I thought myself entitled to infer, that barometers of the usual construction, however carefully made, must be liable to a gradual deterioration from the slow insinuation of air between the mercury and the tube. It was a subject of regret with me, at the time, that I had not been able to find any registers, except that of the Royal Society to the year 1816, which had been continued for a sufficient length of time with the same instruments to furnish satisfactory evidence of this interesting process. I have, however, lately been more successful in my researches, and I have now the pleasure of laying before the society that which I think they will consider as sufficient proof of this important fact.

In the *Ephemerides* of the Meteorological Society of the Palatinate, from the year 1781 to the year 1792, published at Manheim, is a series of observations kept with the utmost care and attention at upwards of thirty of the principal cities of Europe. The first astronomers of the continent did not at that time think the science of meteorology beneath their notice, and themselves attended to

the irksome labour of registering the indications of the instruments, and calculating the mean results. Whoever will take the trouble of examining these faithful and laborious records, must come to the conclusion, that this branch of natural knowledge not only has made no progress since the unfortunate dissolution of this society, but has seriously retrograded both as to the accuracy of the instruments of research, and the proper method of pursuing the investigation.

From the immense repository of these volumes I have selected* eight registers, in which the same instruments, all carefully compared together, were used during the greatest length of time; and from them I have extracted the following mean annual heights of the different barometers. The observations were taken three times in the day, and the means are calculated from all the observations:—

The FIRST series is that of Manheim, which consists of 12 years, from 1781 to 1792 inclusive: this I have divided, in the following table, into two periods of six years each. The height of the barometer is registered in French inches, lines, and tenths:—

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .	27	9	9	1787 . .	27	9	8
1782 . .	27	9	3	1788 . .	27	9	6
1783 . .	27	9	6	1789 . .	27	8	3
1784 . .	27	9	1	1790 . .	27	9	2
1785 . .	27	9	9	1791 . .	27	8	9
1786 . .	27	9	4	1792 . .	27	7	5
Mean . .	27	9	5	Mean . .	27	8	8

From this it appears that the mean of the last six years is .7 of a line, or .062 in. English lower than that of the first six. The SECOND series is that of Padua for the same twelve years, divided into similar periods.

* It has, I understand, been insinuated, that these examples have been selected, *because* they gave results favourable to my hypothesis, whereas the candid inquirer might have learnt by a proper reference, that these were the only instances which were calculated to throw any light upon the subject, from the length of time during which they were continued.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .	28	0	84	1787 . .	28	2	1
1782 . .	28	1	05	1788 . .	28	1	5
1783 . .	28	1	65	1789 . .	28	1	46
1784 . .	28	1	2	1790 . .	28	2	7
1785 . .	28	1	68	1791 . .	27	11	2
1786 . .	28	1	7	1792 . .	27	10	1
Mean	28	1	3	Mean	28	0	8

The result of this comparison is, that the mean of the last six years is lower than the first six .5 of a line, or .044 English inch.

The THIRD series is that of Rome, in which, however, the first year is deficient, the observations not having been commenced till the year 1782.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .				1787 . .	28	0	6
1782 . .	27	10	49	1788 . .	28	0	3
1783 . .	27	10	71	1789 . .	27	9	3
1784 . .	27	11	7	1790 . .	27	9	0
1785 . .	28	0	2	1791 . .	27	10	2
1786 . .	28	0	5	1792 . .	27	8	3
Mean	27	11	5	Mean	27	10	2

The average of the last six years is here lower than that of the first five 1 line .3, or .114 English inch.

The FOURTH series is that of Buda, which likewise wants the first year.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .				1787 . .	27	5	98
1782 . .	27	5	76	1788 . .	27	6	2
1783 . .	27	6	09	1789 . .	27	3	5
1784 . .	27	5	89	1790 . .	27	6	5
1785 . .	27	5	90	1791 . .	27	5	9
1786 . .	27	5	85	1792 . .	27	4	6
Mean	27	5	8	Mean	27	5	4

The difference is here .4 line, or .035 English inch.

The FIFTH series is that of Brussels, which, however, consists of only eight years, wanting the four first.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1785 . .	27	10	72	1789 . .	27	8	7
1786 . .	27	9	98	1790 . .	28	0	9
1787 . .	27	10	0	1791 . .	27	9	9
1788 . .	28	0	5	1792 . .	27	9	9
Mean	27	10	8	Mean	27	10	3

The difference between the means of the first and second four years is .5 line, or .044 English inch.

The SIXTH series is taken from a higher station; viz. Munich. The first six years are complete, but the eighth is wanting.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .	26	5	69	1787 . .	26	6	3
1782 . .	26	5	01	1788			
1783 . .	26	5	35	1789 . .	26	3	8
1784 . .	26	5	50	1790 . .	26	6	9
1785 . .	26	4	99	1791 . .	26	4	8
1786 . .	26	4	88	1792 . .	26	2	8
Mean	26	5	2	Mean	26	4	9

The mean of the last five years is lower than that of the first six .3 line, or .026 English inch.

The SEVENTH series is from the summit of Peissenberg, a lofty mountain in Bavaria

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .	25	0	14	1787 . .	24	11	89
1782 . .	24	11	27	1788 . .	24	11	73
1783 . .	24	11	42	1789 . .	24	11	09
1784 . .	24	11	03	1790 . .	25	0	1
1785 . .	24	11	36	1791 . .	24	11	28
1786 . .	24	11	07	1792 . .	24	8	9
Mean	24	11	3	Mean	24	11	0

The number of years is complete, and the mean of the first six is .3 line higher than that of the last six, or .026 English inch.

The EIGHTH and last series is taken from the summit of Mount St. Gothard. The first year only is deficient.

Year.	Ins.	Ls.	Tenths.	Year.	Ins.	Ls.	Tenths.
1781 . .				1787 . .	21	10	2
1782 . .	21	8	91	1788 . .	21	9	0
1783 . .	21	10	0	1789 . .	21	9	9
1784 . .	21	9	3	1790 . .	21	10	3
1785 . .	21	9	7	1791 . .	21	8	0
1786 . .	21	9	24	1792 . .	21	7	4
Mean	21	9	4	Mean	21	9	1

The mean of the last six years is lower than that of the first five .3 line, or .026 English inch.

All these examples clearly concur in establishing the supposition of the gradual depression of the mercurial column by the infiltration of the air. There is also another conclusion, derivable from the same facts, which might have been anticipated from theory; namely, that the amount of the effect depends, in some degree, upon the elasticity of the atmosphere in which it takes place. The five series of observations whose mean pressure is 29.235 inches English, show an average depression of .59 inches in twelve years; while the three series whose mean pressure is 25.977, exhibit a depression of only .026 inch in the same interval.

From the same valuable record of facts I have also derived a strong confirmation of my opinion of the manner in which the air gains access to the vacuum of the barometer; that is to say, that it is by means of the glass, and not of the mercury. While I quote the observation in support of my ideas upon this subject, it will at the same time serve for a specimen of the skill and exactness with which all the proceedings of the Society were regulated. The observation occurs in the directions given by the Secretary Hem-

mer for boiling the mercury in thermometers. He thus expresses himself, "Notatu perquam dignum hoc in labore est, nihil ingentis illius vis bullarum aërearum conspici, quæ, ubi mercurius sine igne immissus fuit, inter hunc et vitrum in coctione apparere solent, *manifesto indicio, eas non tam a mercurio quam a vitro provenire*, cujus parietibus adhærebant, quemadmodum in universum omnes corporum superficies densiore aëris lamina stipatas esse et ratio et experientia evincunt. Hanc aëris massam jam tum a cylindro expuleram, cum exiguam hydrargyri portionem initio immissam fortius ebullire facerem unde quæ in secunda coctione in conspectum veniebant bullæ admodum raræ erant."

With regard to the experiment which is going on with the platinum guard, which I had the honour to suggest to the Society, its progress is such as I anticipated. A comparison has lately been made of my own barometer, to which this contrivance was applied about fifteen months ago, with the standard of the Royal Society, and also with two barometers which have have been recently completed by Mr. Newman for Professor Schumacher, both of which are furnished with the guard; the particulars of this comparison I shall now detail. I must, however, first premise that some of the principal air-bubbles, which I have before described, near the top of the mercurial column in the Society's instrument, have passed up into the vacuum, as I have ascertained by circular marks which I made upon the exterior of the tube from which they have gradually moved away.

My mountain barometer agreed exactly with the Society's barometer when first it was made; and Mr. Newman also made another for his own use, which was in perfect accordance with them. The latter, however, was not provided with the platinum ring.

The following observations were made by Mr. Newman:—the barometers having been allowed to hang, side by side, for an hour before their heights were taken. The first comparison was between a mountain barometer, for Professor Schumacher, provided with an apparatus for adjusting the level of the mercury in the cistern with Mr. Newman's standard, which gave the following result:—

	Newman's.	Prof. Schumacher's.
	29.850	29.860
Capacity	—.007	—.——
	29.843	29.860
Capillary action	+.040	+.026
	29.883	29.886

From which it appears that the fresh-boiled barometer stood .003 inches higher than the other which had been made eighteen months, and was unfurnished with a guard.

The next comparison was between the same barometer of Mr. Newman, the Royal Society's standard, a fresh-boiled mountain barometer of Professor Schumacher, and my own barometer, with the platinum ring.

Royal Society's.	Mr. Newman's.	Prof. Schumacher's.	Mr. Daniell's.
29.996	29.960	29.968	29.956
—.006	—.005	—.002	—.002
.990	.955	.966	.954
+.003	+.040	+.033	+.044
20.993	29.995	29.999	29.998

From which it appears that the two unguarded barometers stood lowest in the scale, and that that which had been longest made was most depressed; while the guarded barometer agreed with the fresh-boiled barometer in standing higher than the other two. It is true that the difference of .006 inch is but small, but the depression is as much as could have been expected in the time; and the five observations being consistent together, will be allowed, I imagine, to give great weight to the conclusion*.

* There is a defect which may often be observed in old looking-glasses which may probably be referred to the same cause as the deterioration of barometers. I allude to a dulness which takes place in large spots over their surface, and which generally seems to radiate from a centre. I have frequently remarked this in the very old mirrors in some of the palaces upon the continent. I imagine that this arises from the slow insinuation of air by the edges, or some accidental crack in the metal at the back of the glass. It is also, I understand, well known to the dealers in mirrors, that when placed against a damp wall, looking-glasses are particularly liable to become cloudy; and it is most likely that moisture greatly facilitates the action to which I have been referring.

It now gives me the greatest pleasure to be able to communicate a confirmation, not only of my own ideas upon the gradual insinuation of air between mercury and glass, but also of Mr. Faraday's observations upon the same subject, the accuracy of which have been, very unnecessarily, called in question. The authority upon which this confirmation rests is that of Dr. Priestley, whose acuteness of observation few, I imagine, will presume to doubt. The following extract is taken from the third volume of his Observations on Air (p. 336, and sequel), published in 1786:—

"In the course of these experiments with the sun, I observed a remarkable source of fallacy with respect to the increase of the quantity of air confined by mercury, when there is so much moisture in the inside as to be subject to sudden dilations and compressions. For a considerable quantity of common air would get into the inside of the vessel when there was the depth of an inch of mercury on the outside of it, and of two or three inches within. In these circumstances I have seen more than an ounce-measure of the external air gain admission in less than one minute. This must have been occasioned by the mercury never being in perfect contact with glass; so that when the mercury was in a state of undulation, the air that was confined between it and the glass was continually protruded, and more air from the atmosphere was forced into its place, by the same pressure which supported the column of mercury within the glass. This effect I prevented by having a quantity of water upon the mercury on the outside of the vessel. For this would be in perfect contact with the glass; and in this case I never found either air or water to get into the vessel to disturb my experiment."

From these few facts thus briefly, but clearly, described, the whole of my conclusions with regard to the barometer might have been deduced with as much justness as from the more extended and varied observations upon which I have hitherto rested them. If mercury, in Dr. Priestley's experiments, could not be brought in perfect contact with glass, neither in the common construction of a barometer can it so be brought. And as,

when the mercury in his jars was in a state of undulation, the air that was confined between the two was continually protruded; so, in the barometer, will it ascend by the continual oscillations and vibrations to which it is exposed.

Again—Dr. Priestley argued, that a fluid which would be in perfect contact with the glass would effectually interrupt this action; and he accordingly found that when he put a quantity of water upon the mercury, on the outside of the vessel, neither air nor water got in to disturb his experiments. It follows, therefore, that if perfect contact between the mercury and any complete circle of the barometer tube can be produced, the air will be effectually prevented from ascending into the vacuum. I have already described an easy method of producing this contact.

To enable the Society better to judge of the state of a question, which I cannot doubt they will consider of some interest, I shall now beg leave to make a brief recapitulation of the conclusions of the present paper, and of the two former papers, which the council have done me the honour to place amongst their archives.

First—I have established the fact that air gradually insinuates itself into the best-made barometers of the common construction.

Secondly—I have shewn that this cannot take place by means of any solution of the air in the mercury.

Thirdly—I have proved that the passage of the air is between the mercury and the glass.

Lastly—I have discovered a method by which this gradual deterioration may be prevented.

The first fact has been proved * by the visible and progressive ascent of bubbles of air on the surface of the mercury of the new barometer belonging to the Society, in the construction of which very unusual pains were taken †; and also by the ascent of air in other barometers of the best construction.—2ndly, By the gradual deterioration of the old barometer of the Society, as

* *Journal of Science,* vol. xx. p. 84.
† *Meteorological Essays,* p. 349.

proved by the means extracted from the registers, published in the *Philosophical Transactions*, from 1797 to 1816 *.

That air does not enter the barometer tube by being dissolved in the metal is shewn †—1st, By my experiment of exposing mercury, which had been long agitated with air, to the *vacuum* of an air-pump: under which circumstances air is never disengaged from it ‡.—2ndly, By Signor Bellani's experiment, who displaced the metal from a well-boiled barometer, by means of mercury, which had been long exposed to air and moisture, without affecting the height of the column.—3rdly, By the observations above-quoted from Hemmer.

The third fact I have established § by my experiments upon the capillary action of different-sized glass tubes, in which the mercury, which had been boiled in the tubes, became gradually depressed to the amount in unboiled tubes, in proportion as the air insinuated itself between the metal and the glass.—2ndly, By Mr. Faraday's ‖ experiments, in which a mixture of oxygen and hydrogen gases was proved to have passed out of bottles, in which it had been attempted to confine it, and was replaced by common air, while the same mixture was preserved in similar bottles by water.—3rdly, By the similar experiments of Priestley, in which the same action took place more rapidly, on account of the greater vibrations to which the vessels were exposed.

The fourth conclusion follows:—1st, from the experiments of Mr. Faraday and Dr. Priestley; which prove, that when the fluid has affinity enough with the containing vessel to wet its surface, the access of air is cut off; whence ¶ I was led to infer, that a ring of platinum, welded or cemented to the open end of a barometer, and wetted, as it may be, with mercury, would effectually prevent the insinuation of air.—2ndly, From the actual result of the experiment, as far as it has proceeded, which has fully confirmed the justness of the induction.

* *Journal of Science*, vol. xx. p. 89.
† *Meteorological Essays*, p. 364.
‡ *Journal of Science*, vol. xx. p. 82.
§ *Ibid.* p. 82. ‖ *Ibid.* p. 86. ¶ *Ibid.* p. 87.

Art. V.—*An Inquiry into the Nature of the Luminous Power of some of the* Lampyrides, *viz.*, Lampyris splendidula, *or Glow-worm*, Lampyris Italica, *or Fire-fly, and* Lampyris noctiluca. *By* Tweedy John Todd, M.D., Fellow of the Royal Medical Society of Edinburgh, *&c.*

[Communicated by the Author.]

The problem which the phenomena of animal light presents has received different solutions, generally influenced by the reigning philosophy of the times. The older naturalists, associating the appearance with that which sometimes arises from dead animal matter, ascribed it to putrefaction. Forster, Spallanzani, and de Grotthus, considered it a form of combustion. Beccaria and Monti, academicians of Bologna, likened it to the phosphorescence of minerals. It remained for Carradori and Macartney to shew, that it was of the domain of pure vitality, an action of organic life. To add some illustrations of this last opinion is the object of the following pages.

The light of the Lampyrides * varies as the species and their sexes, and as the animals are imperfect or fully developed.

In the female glow-worm the light is of a bright topaz colour, with rather a tinge of green, shining like a lamp, "*laterum et clunium colore* †." It is visible at a considerable distance, but its illuminating power is weak, not extending beyond a few inches. Within that space, however, it is easy to discern any object, as, for instance, to observe the hour by the watch. This light, from its commencement, is constant and unintermitting, but varies sometimes in its degree of brilliance.

The light of the male glow-worm is of the same colour, but more feeble than that of the female. It is confined to two very small round spots, and is rarely exhibited spontaneously, unless in certain sexual relations. Hence this animal has generally

* Cuvier. *Règne Animal.* † Pliny.

been considered to be void of light. But the least irritation or pain at any time excited, is sufficient to cause the instantaneous appearance of the light.

The female of the *Lampyris noctiluca* *, as I supposed it to be, excels all the rest in the beauty of its light. It is steady and constant, of a bright bluish or greenish colour, and seems to envelop the whole of the insect. Its illuminating power, however, does not exceed that of the glow-worm.

The male of the Lampyris noctiluca shews a soft and delicate bluish light. It intermits slowly, appearing and disappearing at intervals of the duration of several seconds.

In the fire-fly, the power of producing light is of two degrees. The first resembles that of the glow-worm, being rather more faint, but from its commencement equally constant and unintermitting. The second, which forms its distinguishing character, is a vivid white light, intermitting instantaneously, like scintillations or sparks of fire suddenly extinguished, "*ut fulgor igni similis alarum compressu tegatur* †." Its illuminating power surpasses that of the glow-worm, and all other animal light. In the brightest moonlight the light of the fire-fly may be distinguished, whilst that of the other luminous insects is not to be perceived, and hence they never shine in moonlight, unless they find a shade.

Observing the luminous organ of the fire-fly during its intense action, or during the transition from the first to the second degree of light, it appears as if a membranous veil were removed from the surface of the organ, exposing a bright flame, and suddenly closing again. It was probably this appearance which led Pliny

* This insect, which I have not seen described, is about four lines in length, of the general form of the female glow-worm, and like it without wings. It is of a pale yellow colour, except the head, which is black. Its antennæ are simple, and its corselet of a semicircular form, having two transparent crescentic spots on each side, receives the whole of the head. It has eight abdominal rings, the two last of which are patched, as the female glow-worm, with opaque, sulphur-coloured spots, besides two spots on each side of the back, placed laterally in the first and penultimate rings.

† Pliny.

to suppose that the intermission of the light, which he calls "*miraculum solicitum,*" was effected by the opening and closing of the wings, "*nunc pennarum hiatu refulgentes, nunc verò compressu obumbratæ.*" Carradori and others have fallen into a similar error, by imagining that a membrane was really drawn over the organ*."

The larva of all the foregoing insects have also the property of giving out light. It is faint, of a yellowish colour, and slowly intermitting.

Even the ova of these insects have the power of emitting a form of light. It is a feeble glimmering glow, like that proceeding from phosphorous, and only to be distinguished when the ova are amassed together. The same light may also be observed issuing from all the lower surface of the abdomen of the female glow-worm, when about to deposit its ova. It increases when the abdomen is opened, and the ova are exposed, and continues in the ova when they are removed from the animal.

These insects make their appearance in Italy about the end of spring or beginning of summer, later or earlier, according as the season is more or less favourable. First, the glow-worm, next the fire-fly, and last, the Lampyris noctiluca. According to my observations, the glow-worm requires a mean temperature of about 50°.7 for its appearance, and the others about 55°.7. Pliny connects their appearance with that of the Vergiliæ and the progress of vegetation, "*atque etiam in eodem arvo est signum illius* (*hordei*) *maturitati, et horum* (*panici miliique*) *stationi commune, lucentes vesperè per arva cicindelæ. Ita appellant rustici stellantes volatus, Græci vero Lampyridas, incredibili benignitate Naturæ*†.

The Lampyris noctiluca disappears first, and, indeed, in very bad seasons is rarely observed. The fire-fly soon follows it, having generally continued to shine from six weeks to two months. The glow-worm does not retire until the month of

* *Giornale di Brugnatelli.* 1808, 1809.

† *Historiæ Naturalis,* lib. XVIII. cap. xxvi. sect. 66.

September. The larva of these insects begin to shine about the middle of June, and may be observed as late as October.

The usual period when they begin to shine, is about the end of twilight, the light first appearing in one point, and then extending to the whole of the luminous organ. The fire-flies and the Lampyrides noctilucæ may generally be seen mixing with each other; but the former fly more generally about the hay or corn fields, and the latter prefer the woods. The glow-worm generally chooses a conspicuous part in fences; and as the luminous organ is seated on the lower surface of the abdomen, its light in the usual position would not be visible, it lies, therefore, on its side, and projects the under surface of the abdomen, which is in slow and constant motion, so as to display its light to the greatest advantage.

Twilight only affects their shining, as being the period of the transition from light to darkness, for if they are placed in a dark situation, they begin to shine long before twilight. If also whilst shining they are exposed to the light, they soon cease to give out light, and if the light be removed, they begin to shine again, and so on alternately.

Morning also only puts an end to their shining, as being the period of light; for if they are preserved in a darkened room, they continue to shine for several hours after daylight *.

It has been observed of them as of the *Scolopendra electrica* †, that if, by any contrivance, they have been secluded from the sun's rays during the whole day, they do not shine spontaneously in the evening ‡. But this arises from their not being, under such circumstances, sensible of the change from light to darkness. I have preserved several of all the species in the dark during the day, and they have, notwithstanding, shone spontaneously in the evening, and much earlier when the light is purposely withdrawn.

* The glow-worm shews that matin is at hand,
And 'gins to pale her ineffectual fire.

† Macartney. *Philosophical Transactions.*

‡ Macaire. *Bibliothèque Universelle de Génève.*

The power of shining depends much on the vigour of the animals. When from any privation they become languid, their power of shining is lost: and when under these circumstances the animals die, it is almost impossible, by any means, to excite the light. The contrary is the case after any sudden or violent death.

Section II.

Examination shews that the power of giving out light is confined to certain parts of the body, which do not occupy the same place in the different species.

In the female glow-worm the luminous power is confined to some straw-coloured patches, more opaque than the neighbouring parts, which may be observed on the under surface of the three last abdominal rings. Sometimes, although rarely, they are also to be observed on the four last abdominal rings. In the penultimate and ante-penultimate rings, these patches occupy nearly, though irregularly, the anterior half of each, and in the last one a round spot on each side. The luminous organ of the male glow-worm resembles that of the last ring of the female, except that the points are considerably smaller.

The luminous organs of the female of the Lampyris noctiluca are seated on the superior, as well as on the inferior, parts of the body. In the latter they occupy entirely the two last abdominal rings, and in the former they present two round spots, laterally on the first and penultimate rings. In the male they occupy entirely the lower surface of the two last rings.

The fire-fly has the two last abdominal rings entirely occupied by the luminous organs.

In the larva the luminous organs present a crescentic patch on each side of the last abdominal rings.

When these rings are removed, which consist of a thin transparent corneous substance, there is found adhering to them a peculiar matter corresponding to the opaque, straw-coloured patches just described, in which resides exclusively the power of emitting light. This matter* is adhesive, like animal gluten,

* A whitish, pasty matter—Carradori. A semilucid albuminous matter—Macaire.

semi-transparent, but soon becomes opaque on exposure to the air, assuming in that state a yellowish-white colour. As regards its transparency, we are very liable to be in error, for if in any degree illuminated, it appears perfectly so. It is in some degree granulated, "*disposée en grains organizés**", or at least some parts of it are more consistent than the rest, and therefore present that appearance. This opinion is also favoured by the unequal distribution of the light through this matter, appearing at times to be confined to particular points or grains. Besides being granular, it is said to be organized like the common interstitial matter of the body, but of a closer texture, and paler yellow colour; and that of the posterior ring is said to consist of two organized sacs, containing a soft yellow substance of a more close and homogeneous texture than that of the anterior rings †. According to Macaire, this luminous matter is also penetrated by nerves; for in dissecting the female glow-worm, he observed several nervous filaments, of a reddish-white colour, going to be distributed throughout the organ.

This substance is perfectly luminous in its state of integrity, but soon loses that power on being disorganized or broken down. By exposure to the air, also, it loses its property of shining; and although the light may be re-excited for a time by mechanical or other irritation, it invariably ceases to give out light sooner by exposure to the air than when preserved from it. This, by Carradori, is attributed to losing its moisture. In proof of this opinion, he says, that if it be dried in its proper receptacle, it loses the power of emitting light after three or four days; but if confined between two plates of glass closely pressed together, the power of giving light is preserved for a longer time; and besides, that, when the organ is entire, and preserved in oil, it affords to give light for a much longer time than when dried, and that, when dried, the power of shining, although in a very faint degree, may be restored within the space of four or five days by moistening it ‡.

* Macaire. *Loc. citat.* † Macartney. *Loc. citat.* ‡ Ibid.

My own observations do not agree with these. I have never been able to preserve this matter with the power of giving light so well or so long as when it is left in its proper receptacle, the essential means of preserving its luminous property being to preserve its organization, for although it shines when broken down, it is but for a moment, and only, as it were, whilst being destroyed.

According to Macaire, this substance, considered chemically, consists principally of albumen, losing its power of giving out light, and its particular structure, by coagulation. Chemistry, however, does not reveal to us, that from its chemical constitution proceeds its light. It is found to be uninflammable, and not more combustible than any other kind of animal matter.

When this matter is examined, after having lost all its vital properties, although its natural structure be preserved entire, I have found it to be perfectly incapable of affording light by any contrivance which I have been able to imagine. But if it be examined after being recently removed from the living animal, it is found that, if shining spontaneously, its light gradually ceases. The longest period, during which I have observed the light continue in the organs after amputation, was twenty minutes. If, however, the separation be made when the organ is not in action, light is partially, and sometimes generally, excited, as in the former case, soon to be gradually extinguished, shewing the influence of mechanical irritation or pain, on the sensibility of the organ.

The light which is emitted by the organ when separated from the animal, continues equally long in media of very opposite properties: thus, as long in mephitic gases as in those capable of supporting combustion *. Neither is it extinguished in vacuo *, under mercury *, in water †, or in oil *.

The acid and ammoniacal gases acting chemically on the matter exposed to them, without its covering, extinguish the light by destroying the structure of the organ ‡.

When the light has ceased spontaneously in the amputated or-

* Carradori. † Macartney. ‡ Macaire.

gan, it may be restored by any irritation. Thus, pricking the organ with a needle, rubbing it, and sometimes even drawing a hair-pencil over it, is sufficient for this purpose. Thus all chemical irritants excite the light; but those acting chemically on the structure soon extinguish it *. Thus heat and cold equally excite the light. Ice, applied to the organ, excites the light; but continued for any length of time, it extinguishes it †. If, when shining, the organ be exposed to a temperature of about 95°.7, light continues to be emitted; but if the temperature be raised to 135°, or lowered to 77°, it entirely disappears. When, also, these insects are killed by being exposed to a temperature not exceeding 122°, by raising the temperature to about 144°, the organs begin to shine; the light, however, soon ceasing, nor can it be restored by any means *.

The action of the galvanic pile also causes light to be emitted by the luminous organ, either when it has been removed from the rest of the body, or in the recently-dead animal. Thus, by applyng to the abdominal nerves one pole, and to the extremity of the abdomen the other, I was able to illuminate the whole of the first abdominal ring. The second ring was not affected; but, on separating it from the other, and exposing it to the action of the same galvanic pile, it became perfectly luminous, and when the light ceased, it was easily re-excited by renewing the action of the pile. Electricity produces also the same effect.

Animal excitants, as alcohol, camphor, ammonia, &c., act energetically on the luminous organ. By means of these, I have frequently observed vivid scintillations from the organ of the fire-fly, several hours after it has been separated from the animal; and when the light has been produced by their application, it continues to be emitted, although in a feeble manner, without any intermission, for a considerable time. In some instances I have observed it for three days.

In all the preceding observations, I have remarked that the luminous organ of the fire-fly was the most sensible of the action

* Macaire. † Carradori.

of external agents, whilst that of the glow-worm continued to be acted on for the greatest length of time.

It is, however, to be understood that there is at all times a marked difference between the spontaneous illumination of the organ, and that induced by artificial means.

Having considered the influence of several agents acting on the organ and its luminous matter, when separated from the animal, let us now examine their effects when acting on the animal itself.

All agents which produce pain excite the appearance of the light, as all mechanical and chemical irritants.

The mephitic gases extinguish the life of the animal, and the light, if shining at the time *.

The irritating gases, as the nitrous acid, the oxymuriatic acid, and ammoniacal gases, destroy the insects, but excite the action of the organ †. The oxymuriatic acid causes the light to assume a reddish colour ‡.

Oxygen and nitrous oxide increased the brilliance of the light, probably as increasing the vigour of the animals §.

All chemical and mechanical agents, generally, which irritate, excite the light; those which disorganize ‖, destroy it.

Heat and cold affect the light in the living insect as in the recently-dead one, or as in the organ when separated from it. Thus heat, to a moderate degree, excites the light; to a greater degree, increases the light, but destroys the animal. Spallanzani says the light is excited from 79° Fahr. or 86° to 99°. According to Carradori the temperature of 104° excites the light, but, if continued, destroys the animal. According to Macaire, with whom I am inclined to agree, raising the temperature from 57° to 81° excites the light; at 106° it shines bright, and, although the insect dies, the light continues; at 135° the light is totally and

* De Grotthus, *Annales de Chimie,* tom. lxiv.

† *Idem. Loc. citat.* Carradori. *Loc. citat.*

‡ Macaire.

§ Davy, cited by Macartney, Forster, Carradori, loc. cit. Macaire, *Bibliothèque Universelle de Génève.*

‖ Macaire. *Loc. citat.*

entirely extinguished. According to him, the light is generally excited between 77° and 88°, and is generally extinguished between 138° and 144°. At 95° the light continues, although the animal dies; but is extinguished when it descends below 77° *.

Cold, as long as it irritates, excites the light, but being long continued, extinguishes it. When exposed to the temperature of 32° Fahr. the insects die, but on being heated again to 88° the light reappears. When insects are shining spontaneously, and exposed to cold, the light gradually diminishes, and ceases entirely at 54° Fahr.†

Various animal excitants and poisons have a very peculiar influence over the action of the luminous organ. Thus, when these insects are killed by alcohol, an alcoholic solution of iodine, tincture of black hellebore, tincture of nux vomica, prussiate of mercury, or ammonia, after all light and symptoms of animal life have ceased, another fixed and steady light, not affected by external light or darkness, reappears in the organ, commencing first in the upper part of the anterior ring, and gradually extending itself to both. It shines bright for an hour, and then becomes duller; in which degree it continues to shine equally and constantly for different periods of time, varying from twelve hours to four days.

Sometimes, in insects poisoned by the above agents, the permanent fixed light begins to appear before life is extinguished, and in the fire-flies before the power of scintillating voluntarily is lost; the permanent light, however, continuing during the intervals of the scintillations.

When the insects survive the effects of these poisons, as they sometimes do, the permanent fixed light continues the same as in those which have not survived, without any regard to external light or darkness, shewing the change induced by the poisons to be an excitement or state of erethism of the organ, not subject to the voluntary power of the animal.

With regard to the different degrees of susceptibility of the

* Macaire. † Carradori. *Loc. citat.*

different species of the influence of poisons, I have not remarked anything particular. The larvæ in general, however, I found much more difficulty to be acted on than the perfect animals.

The foregoing facts speak so plainly, they do not, in my opinion, require the aid of any formal conclusions. They prove unquestionably this phenomenon in all its bearings to be purely a vital action, and that external causes only influence it, as they affect the vitality of the animal, and the sensibility of the organ.

This result, not however stated for the first time *, deserves more consideration than it has yet received. It places before us a new power of animal life, resembling nearly the phenomena of animal heat, the power of separating light from its combinations with matter.

The use which the luminous power serves in the economy of these insects has not been precisely ascertained. My own observations would rather dispose me to receive the opinion of Reaumur, that by means of the light in the season of sexual intercourse, the sexes distinguish each other. In proof of which it may be stated that the males are constantly attracted by lights, artificial as well as natural, and frequently the males of one species are apparently attracted by the light of the female of a different species, not discovering their mistake until they have approached them. The imperfect animals having also the power of emitting light, as observed by de Geer, it has been adduced against the above opinion, that if such were the purpose of this property, with them it is useless. But many organs are partially developed in animals before they arrive at their state of perfection, when such organs are called into use. Besides, it does not follow that it may not have others. As this light serves to preserve the species, may it not also serve to defend and preserve the individual?

What may be its use in the general economy of nature, it is still more difficult to say.

* Carradori, Macartney.

Art. VI.—*Present State of the Manufacture of Sugar from the Beet-root in France.*

[From a Correspondent.]

It is well known that during the latter years of the late war with France, the manufacture of beet-root sugar was carried to a considerable extent in that country, in consequence of the whole of the French colonies having been captured by Great Britain, excepting St. Domingo, which had been lost as a colony, and almost all its sugar plantations destroyed, since the year 1797; and Bonaparte having, in order to carry on his favourite scheme of excluding British colonial and manufactured productions from the continent of Europe, encouraged his ingenious and scientific men to supply the place of transatlantic produce by articles of indigenous growth. Tobacco was grown to a great extent in France, Holland, and the Rhenish provinces, and the use of West India coffee was very much supplanted by the preparation of a powder, formed principally from the root of a species of endive called chicory. But the labours of the men of science were particularly turned to the production of sugar from grapes, beet-root, and other plants. Of the growth and success of these branches of industry several memoirs were published in France, particularly by M. Chaptal, in 1818, and M. Dombasle, who undertook the manufacture of sugar with the advantage of great chemical knowledge, as well as government patronage. These undertakings prospered as long as the war continued (being protected by an enormous duty on all sugar of foreign growth); but as soon as the events of 1813 and 1814, which led to the peace, caused the sudden introduction of West India sugar through Holland, &c., they were suddenly ruined, by the comparatively low price at which the foreign sugars were introduced (at first very much by smuggling), and the necessity which the government felt of relaxing in its rigorous decrees against foreign commerce. As, however, the prices of sugar rose again after the peace of Europe was

established, several of the old beet-root sugar-manufactories of France, which had been sold for a very small proportion of their cost at the end of the war, were opened again, and in 1819 they were in considerable activity, the price of sugar being then 8*d.* *a* 9*d.* per lb. in France, and the supply of the French colonies not adequate to the increasing consumption, and the duty on that of foreign growth being about 3½*d.* per lb., whilst the sugar made in the the French colonies was also charged with a duty of about 1⅓*d.* per lb. Since that period, the beet-root manufacture appears to have increased, notwithstanding the decline in prices (which fell to 4½*d.* *a* 5*d.* per lb. for raw, or Muscovado); and a work was published last year by a Mr. Dubrunfaut, who visited all the principal works in France, describing minutely their present condition, and the various improvements lately introduced, with the closest calculations of the cost of production. The manufacture of sugar from grapes does not appear to be continued to any extent worth noticing; but the author states that above one hundred beet-root manufactories are in full work, and that they are increasing.

Before entering on these particulars, it may be well briefly to state that the extraction of sugar from beet-root appears to have been first attempted with some success in 1747, by the Prussian chemist Margraff, on a small scale; and about forty years after by another Prussian chemist, Achard. Their experiments made some noise, but did not lead to a practical application on any considerable scale. In 1800, the French Institute appointed a commission to inquire into the subject; and it appeared, from the experiments then made, that the sugar could not be produced at a less cost than 8*d.* per lb.; but a few years afterwards, the savants of France discovered better and more economical methods of extracting sugar from beet-root, as well as grapes; and in 1810 and 1812 the establishments were extending and prosperous.

In Volume xviii. of the *Transactions of the Society of Arts*, (published in London, in 1800,) a paper was published, written by Mr. John Taylor, at Leipsic, containing a particular account of the practical experiments made in Germany, to produce sugar

from beet-root: he states, that for this purpose there were used several varieties of the beta vulgaris, or beta caule erecto of Linnæus, principally the beta rubra vulgaris, or red beet of the English, and the beta cicla, den weissen mangeld of the Germans, or the white English beet. The roots were dried considerably, and then put into a succession of tubs, filled with cold water, and the sweet extract, or juice, run off, and boiled down as quickly as possible, into a syrup, which was then reduced to a state fit for crystallization, and cleared after the manner used in the West Indies; the remaining thick syrups being afterwards either distilled into rum or used as treacle. He details also the experiments of Professor Lampadius, of Fribourg, who produced from 110 lbs. of the white English beet, after it was washed, peeled, cleaned, and then grated, a mass of 87 lbs., out of which were pressed 41½ lbs. of juice, which was boiled with 20½ oz. of charcoal powder; this when filtered and evaporated down until crystallized, produced fully 5 lbs. of a brownish yellow-grained sugar, and 5 oz. of brown syrup. This brown sugar, after being dissolved in 6 lbs. lime-water, mixed with 1lb. of blood, then boiled, filtered, and evaporated, yielded 4 lbs. 5½ oz. of purified brown sugar, and 6½ oz. molasses. The residuum was mixed with 1 quart of yeast and 80 quarts of water, and heated to 112° Fahrenheit; and after fermenting 48 hours distilled into a weak spirit, which, when rectified, produced 3½ quarts of spirit resembling rum. Mr. Taylor says, that it appeared from the various experiments made by these simple processes on a small scale, (such as any farmer might adopt,) that after paying the farmer for the roots and all incidental expenses, a profit resulted of nearly 100 per cent.; and the most sanguine hopes were entertained of the manufacture being established throughout the Prussian and German States, so as to supplant the sugar imported from foreign parts. He admits, however, that the produce of sugar varied much in different seasons, the roots sometimes yielding as much as 5 per cent., and at others only 2 per cent. of sugar. It does not appear that the manufacture is at present carried to any extent in any part of Germany.

In France there are several varieties of the beta used for

making sugar. They do not appear to attain so large a size as the same plants do in this country; but it is probable that they contain a greater proportion of saccharine matter, in consequence of the great warmth and less moisture of the climate of France. The quantity produced on an acre in France, of course, varies considerably with the quality of the soil and the seasons; it is sometimes only 12,000 kilogrammes the hectare, sometimes 30,000, (as 1 hectare equals 2½ acres, this is equal to from 5 to 12 tons per acre nearly.) Dubrunfaut gives the expenses of growing the root in ten different estates in France and Flanders, and the quantity produced in each per hectare, specifying minutely all the expenses of rent, labour, *&c.*, the result is the following table:—

		Kils.		per 500 Kils.	
1	—	12,500	per hectare	14 fr.	56 c.
2	—	30,000	,,	9	20
3	—	25,000	,,	7	50
4	—	30,000	,,	6	65
5	—	25,000	,,	8	40
6	—	16,390	,,	9	—
7	—	16,500	,,	8	60
8	—	18,000	,,	7	95
9	—	26,625	,,	6	25
10	—	37,500	,,	10	—
Total		237,515		88	5
Average		23,751		8	80

Of this volume the first ninety pages are devoted to a very minute description of the cultivation of the beet-root, which does not appear to me to differ materially from the culture and management of the same kind of plants in this country.

The proper preservation of the roots (after the leaves are separated) is represented as indispensable to the successful extraction of the sugar from them. They are fully matured in the ground by the month of October, and it would not do to leave them in the fields exposed to wet and frosts;—they cannot be taken (as the sugar-cane is) from the field to the press, but must

be entirely gathered and stored in the dry season, and so kept during the winter months until the end of February, when the process of extracting the sugar is generally finished, (p. 97). If the whole crop was manufactured at once, the requisite works must be more extensive, and the pulp and liquid aliments, which are profitable in feeding cattle, would, in a great measure, be lost. It is stated, as the result of experience, that the beet-root makes the greatest quantity, and best quality of sugar, when it is just taken from the ground, and the quality as well as the quantity gradually decreases as it is kept; much depends, however, on circumstances; if the root is matured by much sun, it produces more saccharine juice, and keeps better, and if it is very aqueous (owing to a moist season) it is less productive, especially if the winter is very frosty or wet. A warm and moist state of the air also appears to cause sometimes a quick decomposition, so that the saccharine juices are never properly preserved, and the plant is only fit for distilling into spirit; the vegetative principle is stated to be very active, so that if the roots are deposited in too large a mass, or too much exposed to moisture and warmth, they either shoot again or ferment too much, or both, so as to destroy a large portion of the saccharine principle, and render the juices acid, and fit only for fermenting into a spirituous liquor; and the more they approach to this state, the more they are also unfitted to be given as food for cattle: the same state which is the best for extracting sugar being also the best for affording nutritious aliment. The author recommends, therefore, that the roots should be kept in a very uniform temperature, about 10° Reaumur, ($10 \times 9 = 90 \div 4 =, 22\frac{1}{2} + 32 = 54\frac{1}{2}$,) equal to 55° of Fahrenheit, with a free access of fresh air, in order to dry them gradually, and preserve the saccharine juices as much as possible. The importance of great care in keeping and drying them judiciously will be evident, if we consider the great portion of water which they contain, and which may be proved by exposing a root to spontaneous desication; thus the author states, that on the 27th of January he left a root in the open air, which weighed 635 grammes, = 1 lb. $6\frac{1}{2}$ oz., which, by the 5th of

March, was reduced in weight to 421 grammes, = 15 oz.; and on the 15th of March, to 336 grammes; about 12 oz.; at this latter period it was soft and wrinkled, and could scarcely be rasped, although in other respects it had not undergone any destruction or visible alteration. The loss of weight will, of course, be the most when the roots are watery, and the least when well matured by a warm dry season, which makes them sweeter, and much easier to keep during the winter. The smaller roots are also stated to keep better than the large ones, even although they do not appear to contain a larger proportion of the saccharine principle.

A long account is given of the different methods adopted for keeping the roots:—1st. In heaps in the open air, covering them up during periods of frost—2nd. In trenches, covered up as potatoes are kept in Ireland generally—3rd. In large pits covered up; and 4th. In magazines. The last of these methods, although so much more expensive, is strongly recommended, as the most productive and economical, where they can be erected and taken care of properly; but the difficulty of drying the roots adequately, but not too much, and of keeping up an even temperature in these stores, is such, that it does not appear they are generally used by the manufacturers in France, and the expense of them would only answer on a large scale.

The author states, that most of the persons in France who carry on the manufacture, make, *not the raw*, but the *refined sugar*, which he condemns, and apparently with justice; for they *must first* make the raw or Muscovado sugar, and if this was sold to those whose sole business it is to refine sugar, it could no doubt be done cheaper and better than on a small scale by the farmer or maker of the raw sugar.

The process of extracting the raw sugar is minutely described, and accurate plates given of all the vessels, apparatus, and instruments, employed.

First. The cleaning of the roots is very carefully done, by washing and cutting away all the green or faded parts, the small roots, &c. &c., which is done by the women, who also reduce

them to nearly the same size, so as to pass freely through the rasping-machine. Sometimes, however, the roots are cleaned without washing; and this is preferred by many, especially if there be a frosty state of the air.

Secondly. As no chemical change is to be made in the constituent parts of the root, the object is simply to extract the saccharine juices as speedily and economically as possible; and the further account of the manufacture will therefore be found to resemble, in many respects, the making of sugar in the East and West Indies, from the sugar-cane. The commencement of the process differs, however: the cane is pressed between two rollers, and the juice is extracted in the most simple form. The beet-root requires a more tedious process: it must be rasped as small and even as possible, that the juice may be pressed out with greater ease, and as free as possible from the fibres, and pulp, and soft matter, which would be mixed in it if it were all pressed together. In order to rasp the root very fine, and with expedition, it seems to be necessary to employ expensive machinery; and several machines are described, in Dubrunfaut's work, of which some are simple and cheap; others more complex and costly; the latter being only used by those who manufacture on a large scale. For the details and respective merits of these rasping-machines, I must refer to the work itself. The quantity of pulp produced varies from sixty to eighty per cent.

Thirdly. The process of pressing the juice out of the pulp is recommended to be performed by the hydraulic-press; but some others are described as in frequent use, especially the wedge-press, such as is in general use not only in France and Holland, but in this country, for extracting oil from flax-seed, rape-seed, &c. &c. The more quickly the pulp is pressed the better will be the juice, and the less likely to ferment or turn sour, which is a risk especially important, and difficult to be avoided.

4. *Défécation.*

The subject of clearing the juice of all foreign matter, previous to its evaporation, is treated very minutely in pages 204 to 302.

As in the manufacture of sugar from the cane it is important to purify the juice as *quickly* as possible, previous to boiling it down, so, in the manufacture from beet-root, it appears still more necessary to use the *greatest despatch* in this part of the process, in order to prevent the expressed liquor from turning sour, and generating carbonic acid, before it is boiled. As soon as it comes from the press, it is described as *d'une teinte laiteuse et noirâtre.* The author details, with great minuteness, the various methods recommended for the *défécation* by Count Chaptal, Dombasle, Crespel, Achard, and other practical as well as scientific men. Many of his own experiments are also given; and the following is an outline of the general process which he recommends, as the result. To put the juice in a boiler of 500 litres (140 gallons), which he considers as the most proper size; to heat it quickly to 65° Reaumur (178 Fahrenheit), and put in 3 grammes of a lime-milk (formed of quick lime and milk-warm water) to a litre of juice = about $\frac{1}{4}$oz. to a gallon. The heat being raised to 70 or 75° Reaumur, the juice then being pretty clear, and the separation of the flakes and scum complete, a small quantity of sulphuric acid is dropped in, diluted with ten times its volume of water at least, which neutralizes the alkali if in excess: the quantity must depend on circumstances; and M. Chaptal states, that it frequently is not necessary to put in any of the sulphuric acid. There seems to be much difference of opinion amongst the theoretical, as well as the practical men, as to the use of this acid; as also of chalk mixed with the quick lime.

5. *Concentration of the Juice* (p. 303 to 342) *and Clarification* (to p. 371).

As the juice still holds in suspension some impurities after it has undergone the process of *défécation* just described, it is necessary, previous to boiling down into the syrup, to concentrate it by a more slow process, and clear away the impure matter which is still held in solution, and which gradually forms into floating lumps, or thick substances, similar to those cleared away by the first process. This appears to be a tedious operation, and

adds much to the expense of this manufacture, beyond that from the sugar-cane, by requiring a set of two, three, or five copper pans appropriated to it, and a considerable portion of time, labour, and fuel, before the juice is brought to that pure and limpid state which fits it for boiling into syrup ready to make the crystallized sugar. Several methods of applying the fire to the pans are described, and the author gives the sizes, number, and arrangements recommended by Chaptal and others. By this process the juice is generally reduced in quantity 75 to 85 per cent.; and in the course of it blood or whites of eggs are used to assist the separation and collection of the impurities.

In the process of *Clarification*, which succeeds to the concentration, the greatest care is required; the most minute directions are given as to the quantities of animal carbon, blood, milk, or whites of eggs to be employed; and it appears as if the syrup of the beet-root juice required much more care than the syrup of the sugar-cane, owing to the former containing originally so much larger a proportion of vegetable and impure matter, and being so much more liable to injury from carelessness, accidents, dirt, or dilatoriness in the several successive processes.

6th. *Filtration, and boiling down of the Syrup* (p. 371 to 420.)

In general the filtration is performed when the juice is at 30° of concentration, but in order to avoid the difficulty and expense of the process at this degree of thickness, some manufacturers do it at 20°. The operation in either case is tedious and expensive to a degree which does not exist in filtrating the sugar-cane juice, on account of the quantity of foreign matter that is still found to be suspended in the beet-root syrup, and the extreme difficulty of making it clear and fit for crystallization. After the filtration is completed, the process of concentration is *finished* in the method described under that name, and this is called the "Cuisson des syrops," which brings it into a state in which it will crystallize. During even this process, a scum sometimes rises, and it is necessary to assist the separation by putting in eggs, or some

albuminous matter. The syrup is reduced by this process nearly one-half, and when it is found to be arrived at the point fit for crystallization, it is poured into the *cooling-vats*, where it remains ten or twelve hours, and is gently agitated, during which time it falls to 60° or 65°, Reaumur, when it is run off into the forms for crystallization; and the author is very particular in directing that the syrup should not cool too much in the vat, as it would in that case not form a good grain, but a soft clammy mass of sugar. When the syrup is found to be not rich enough to crystallize readily, a little raw sugar is distributed at the bottom to assist it. The Muscovado sugar produced by the above process from beet-root, is stated to be preferable for refining to the raw sugar produced from the sugar-cane (at least in the state in which in which it is imported), and it is said to yield a greater produce of refined. But it is admitted by Dubrunfaut, that the raw sugar produced at the end of the season is much inferior in strength and colour to that which is made at the beginning, when the roots are fresh. This disadvantage necessarily results from the large quantity of roots, which could not be all manufactured as soon as they are ripe, without an extent of vessels and apparatus that would be beyond the means of many of the sugar-growers and makers. It appears to be usual with the French makers of beet-root sugar to boil the syrup, or, as we call it, molasses, and extract from it an inferior sugar, a practice which is now adopted in England from West India molasses (whereby about 7000 tons of bastard sugar were produced last year) in consequence of the low price of rum; but when rums are high, the West Indians distil a large quantity of their molasses.

The beet-root, after the juice has been extracted from the pulp, is always used for feeding cattle, and, as it makes a good winter food in the absence of green fodder, this forms a cogent reason for protracting the manufacture from October to April. The farmers mix a small portion of flax-seed cake with the beet-root to make it more nourishing, and the author says that 50 or 60 lbs. of the root, with a flax-cake of about 2 lbs., will feed an ox for a day. Sheep and pigs are also stated to like this food, and to fatten upon it very well.

Cost of Beet-root Sugar in France.

After describing the process, the author gives very minutely an exposé of the cost of the sugar produced from beet-root. Without going into all the particulars, I give here the result for a manufacture carried on regularly during the four winter months.

	Francs	
Premises, repairs, interest, &c.	6800	Equal to about, in English money and weight, 5600*l.* for making 4000 tons roots.
Cost of roots and interest, 16 fr. *a* 20 fr. per ton .	74,583	
Interest on the utensils, &c.	6000	
Labour . . .	17,025	
Fuel	20,588	
Annual repairs . .	4000	
Small charges . .	7000	
Total .	136,082	

Expenses of working 4,114,200 kilogrammes of roots (which is less than Mr. Crespel and others perform every season.)

The produce of this quantity he estimates thus—

As 70 per cent. of juice is extracted, this would leave 30 per cent. pulp, worth 15 francs per 1000 kilogrammes (12 francs per ton) say . . . . 18,514 frs.

Raw sugar $4\frac{1}{2}$ per ct. on the weight of the roots, say 185,139 kilogs., worth 120 frs. per 100 kilogs. =	222,167	
Molasses 153,960 litres = 201,600 kilogs., fit only for distillation, 10 francs per 100 kilogrammes	20,160	260,840 francs
Deduct cost above . .		136,082
Nett return, or profit of the manufacture =		124,758 francs

and deducting from the expenses 136,082 frs. the sum of 38,674 francs, for the value of the pulp and pure molasses, we find a balance of 97,408 francs, which, divided by the weight of the sugar, 185,139 kilogrammes, gives 53 centimes per kilogramme, or about $2\frac{1}{2}d.$ per lb.

This price is, however, below what the article generally costs

in the manufactories of France, which are mostly on a much smaller scale; that of M. Crespel, near Arras, is stated to cost about 62 centimes, or 3¼*d.* per lb., that of M. Cafler, of Douay, 7 *a* 8 sous per lb., the former working on a scale of 2 millions, and the latter of 1 million kilogrammes of roots, in 150 days.

M. Dubrunfaut states, that there are actually in France at present no less than 100 manufacturers of beet-root sugar, which may, he states, furnish altogether from 4 to 5 millions pounds of raw sugar (2000 to 2500 tons) which is not a twentieth part of the consumption of France. The largest manufacturers generally produce 40 *a* 50 tons per annum, some few more; but the average quantity, from his statement, appears to be only 20 *a* 25 tons per annum. He says the manufacturers are increasing in number; but if these data be correct, we are led to wonder why the manufacture has not been extended much more considerably in France, for in that country the duty on imported raw sugar is about 15*s.* 6*d.* per cwt., or rather more than 1½*d.* per lb., from which duty the makers of beet-root sugar are exempted; if they, however, can produce their sugar at 3¼*d.* or 3½*d.* per lb., the manufacture must be a very profitable one, as the selling prices are actually 4½*d. a* 5*d.* per lb., duty paid, and the article cannot be produced in the West Indies, and sold, duty paid, in France for less. Dubrunfaut acknowledges this, and states it as a fact, which ought to encourage the extension of the beet-root manufacture. As, however, it has now been carried on in France to a greater or less extent for above ten years, it seems reasonable to conclude that it does not yield so great a profit as to encourage its great extension, in preference to other commodities, and, consequently, that it cannot be produced (according to the mode of producing it now adopted) so cheap as is represented by Dubrunfaut.

In England the beet-root, I believe, could be produced nearly as cheap as in France, weight for weight; and as the cost of fuel for the manufacture would be much less, (in France it amounts to about 1-6th part of the whole cost of the manufacture, including the price of the roots,) it might be supposed that it would be a profitable manufacture, the more so as the sugar imported from the British West India colonies pays a duty of very near 3*d.*

per lb. But it is probable the root would be much more expensive in working, from its greater bulk, and less productive of sugar, from the juice not being so well matured by the sun as it is in France. I believe the experiment has not been tried.

In Germany and other countries of Europe, the duties on imported sugar are so small, that it is probable this manufacture will not be attempted.

Art. VII.—*On the Use of Lights or Fires in the Fisheries.* *By* J. Mac Culloch, M.D., F.R.S., *&c.*

[Communicated in a Letter to the Editor.]

Sir,

I have taken occasion, in a work on the Highlands to which I need not here refer more particularly, to remark on the singular neglect of our fishermen respecting the use of fires or lights; a practice as ancient as it is common throughout the world, among savage as well as among civilized nations. Some circumstances connected with the fisheries of Cornwall may render it useful at present to recall this subject to the public mind. For the statements, however, I have no authority but the popular one; the representations of individuals, and the paragraphs in the western newspapers; yet I suppose that there can be no great hazard in admitting this as sufficient evidence. The credit, or otherwise, will not, at least, rest with me.

In the salmon fishery, and chiefly in that which is contraband, the use as well as the utility of lights is familiar; and in the work to which I have alluded, I have explained the principle on which it is the object of pursuit to fishes. It is by the light elicited from their own bodies that they become marks to their enemies during the darkness, whether of the night or of the obscure depths of the sea; and thus light becomes, essentially, their leading motive of conduct.

Yet familiar as this fact is as to the salmon, I do not believe that there is a single instance in Britain where this expedient has been adopted in maritime fishing, even by the very individuals themselves, who, from being coast-fishers also, might have been

expected to transfer a practice so obvious and easy, and so demonstrated as to its utility, from one department of their trade to another. Of so little use is knowledge without reasoning. To the maritime fishermen in general, it is probable that the bare fact itself is not known; though we can scarcely conceive how it should not be known, since it must have been witnessed by seamen innumerable, in the Mediterranean and elsewhere. Could it be made publicly known, it might be productive of great advantages; rather, I should say, could the fishermen be induced to follow it; for the one is, unfortunately, by no means a necessary consequence of the other. If a Welshman cannot be induced to fish at all, it is probable that there may be equal difficulty in persuading a Cornishman to light a fire in his boat, though he had seen the practice and its success for half his life. In the particular instance under contemplation, however, even so improbable an event may perchance happen; since the persons concerned in the pilchard fishery have at least the advantage of belonging to a higher class of society; if, indeed, that be a more tractable class than the one far beneath it. Perhaps when education shall spread wider among all classes, and when education shall become somewhat other than it now is, a few of these troublesome impossibilities will vanish.

The fact itself, the utility, is demonstrated by usages so widely spread, that the examples would fill more space than can here be spared to them. That it has been the practice of ancient nations, at various times and places, it would be quite superfluous to repeat. At present, it is found on various parts of the coast of Africa, perhaps on all; as it is no less common in the Eastern islands, and with some of the inhabitants of the South Sea. In the American rivers, it is the constant usage of the boatmen, whether Indians or Europeans; and its success is as notorious as anything can well be. To modern Greece, it has descended from their ancestors; as it is equally the constant usage of Sicily, and indeed of the Mediterranean at large. The effect cannot be questioned. On lighting a fire in the boats, they become immediately surrounded by fish, and it then only remains to take them in the accustomed modes. The process is easy, economical, and

effectual; and it is not easy to see what greater recommendations any practice can possess. It is unnecessary to say, however, that it might be improved for the uses of our fishermen, by substituting a more permanent light, by means of lamps; while it would also be a more economical one.

But to come to the question of the Cornish pilchard fishery, which has been the inducement to these remarks: this is an object which, from its extent and value, is of high importance, not merely to the labourers and consumers, but to the large capital which is sunk in this trade, in the shape of buildings, boats, and nets. With some irregularity, it is a trade which, for some years past, has failed, or the fish have deserted the coasts; and when it is considered that the annual returns were formerly so great, it is easy to comprehend the importance of this defalcation.

In the midst of this, we see in the newspapers, lamentations, almost monthly, coupled with requisitions, to fishermen and philosophers alike, to exert themselves in enticing the fish back again; while no attempt for this purpose has been made, though it might be expected that one so obvious as lights might at least have been tried. It must be hoped that this paper may meet the eye of some Cornish philosopher, considering how Cornwall abounds in philosophers and philosophy, and that another summer will not pass without a fair series of experiments on the affections of pilchards as to light.

And there are reasons to believe that this plan would succeed in this especial case; at least if the current opinions as to the late conduct of the fish can be trusted. It is not said that they have deserted the seas of this coast, but merely that they have fallen into the habit of remaining in the deeper waters; in waters so deep as to prevent the seines from anchoring, a matter essential to this class of fishing. For this conduct they unquestionably possess some motives, whatever those may be: probably it is the position of their food; but whatever it is, our business is, not being able to remove that motive, to offer another, and to entice them into the shallow waters by means of light, whether fixed on the shore, or, as is more plausible, floating where necessary.

In this there can be no difficulty and little expense; and if

another fact which is here stated is also true, then is there every inducement to the trial; as the pilchard is at least proved to be attached to light, like all other fishes, if, in this case, it is not absolutely seduced from the shores by it. The asserted fact is, that they are found near the Eddystone light-house, and not only so, but in shoals directed towards it. Whether this be true or not, this general fact is true; as, in all cases, light-houses are points of attraction for fish, as effectual as they are for woodcocks. And if it be true that the Eddystone light does seduce the pilchards from their, to us, most profitable road, the problem seems to be solved, and the remedy in the hands of the Cornish philosophers.

Should the plan, however, be put into practice, or attempted, it will be necessary that the law should shut its eyes to these lights: or rather, it would become requisite to apply for an alteration in an article of our very brief penal code, which constitutes an act of this nature felony. Whether the Exchequer would consent to surrender one of its guards in favour of this fishery, is a question that remains to be asked.

Art. VIII.—*On the Diagonal Framing of Ships of War, by* George Harvey, Esq., F.R.S.

[Communicated by the Author.]

The following remarks, on the diagonal framing of Sir Robert Seppings, have been drawn up to assist the young naval engineer in the application of a well-known mechanical principle to the forces operating on the parts of that ingenious system; the proofs hitherto offered respecting the relative positions of the trusses and ties having been derived from experiment*, or from considerations foreign to the legitimate purposes of mechanics.

The misconceptions that at first existed on this important subject, arose from a mistake of the proper applications of trusses and ties; the opponents of the proper positions of the ties having

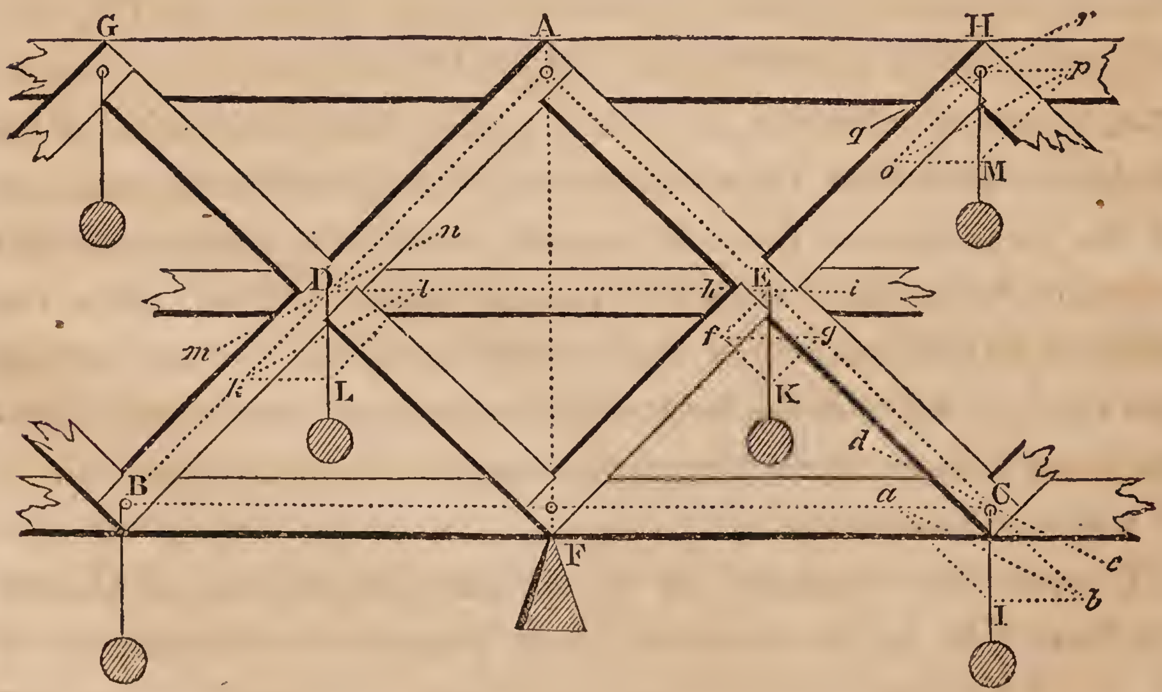
* See Sir Robert Seppings' paper on the 'Great Strength given to Ships of War by the application of Diagonal Braces,' in the *Philosophical Transactions* for 1818.

omitted to consider the essential principle in constructive carpentry, that the force which operates *to extend the tie*, should at the same time tend *to compress the truss*. The mechanical lemma now to be added will enable the young shipwright to distinguish the parts of the diagonal framing subject to extension, and also those subject to compression; and moreover how, by the operation of the extending and compressing forces, the form originally communicated to the framing may be best preserved, and thus prevent, in the greatest possible degree, the arching of the ship.

Mechanical Lemma*.

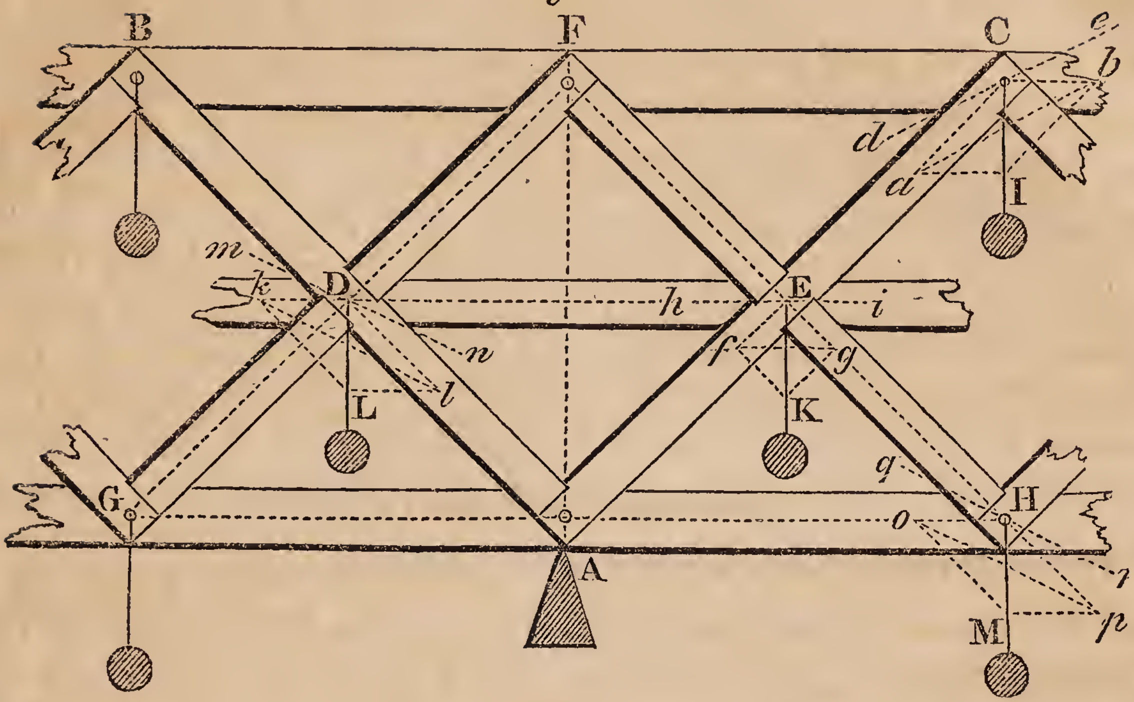
Through the point in which the sustaining forces meet, let a line be drawn to represent the measure and direction of the straining force; and on it let a parallelogram be constructed, as a diagonal, having its sides parallel to the sustaining forces. Draw the remaining diagonal of the parallelogram, and, parallel to it, another line through the point where the sustaining forces meet. Then all the parts of the framing on the *same side* of this line, as the straining force, will be in a state of *compression*, and all those on the *other side* of the same line in a state of *extension*.

Fig. 1.



* For some interesting applications of this well-known mechanical principle, see Mr. Tredgold's chapter on the Equilibrium and Pressure of Beams, in his excellent work on the *Principles of Carpentry*.

Fig. 2.



In figure 1, let A B and A C represent two of the braces or ties of a system of diagonal framing, and G D, D F, H E, E F, corresponding trusses. Let also G H, D E, and B C, denote the longitudinal timbers of the same system, and F the fulcrum on which the whole is supported. Then if we apply the lemma in the first place to the brace A C, and the longitudinal timber B C, at the point C, where these timbers may be supposed to meet, let the vertical line C I be drawn to represent the measure and direction of the straining force operating at that point. On C I, as a diagonal, let the parallelogram C *a* I *b* be constructed, having its sides in the directions A C and B C of the longitudinal axes of the timbers selected for consideration. Draw the other diagonal *a b* of the parallelogram; and through C, where the vertical force is supposed to operate, draw *d e* parallel to *a b*. Then, since the longitudinal timber B C is on the *same* side of *d e* as the straining force C I, it will by the lemma be in a state of *compression;* and the brace A C being on the *opposite* side of the same line, will be in a state of *extension.*

To apply the lemma in the second place to the brace A C, and the truss F E, let the straining force be supposed to be applied at E, and E K denote its measure and direction. Complete the parallelogram E *f* K *g*. Join *f g*, and through E, draw *h i* parallel to *f g*. Then the truss F E being on the *same* side of *h i*

as the straining force, E K, will be in a state of *compression;* and the brace A C, being on the *opposite* side of the same line, will be in a state of extension, as determined in the preceding case.

To apply the lemma in the next place to the brace A C or A B, and the longitudinal timber D E, let the straining force be allowed to act at D, and let D L be its measure and direction. Complete the parallelogram D k L l, and join $k\,l$; and through D draw $m\,n$ parallel to the last-mentioned line. Then the longitudinal timber D E being on the *same* side of $m\,n$ as the straining force, it will be in a state of *compression*, and the brace A B or A C, as before determined, in a state of *extension.*

Fourthly, let the parts now to be selected, be the longitudinal timber G H, and the truss H E. Then if the straining force be applied at H, let H M denote its measure and direction; and on it as a diagonal, let the parallelogram H o M p be constructed, having its sides coincident with the directions of the timbers proposed; join $o\,p$, and through H draw $q\,r$, parallel to it. Then since the truss E H is on the same side of $q\,r$ as the straining force, it will be in a state of *compression;* and the longitudinal timber A H being on the *opposite* side of the same line, will be in a state of *extension.*

Hence it appears, that the resultant of the various forces acting on the diagonal frame proposed, will operate so as to *extend the braces* A B and A C, *and the longitudinal timber* G H; but on the remaining parts of the frame, *viz.*, *the trusses* G D, D F, H E, E F, and the *longitudinal timbers* D E, B C, the effect will be to produce *compression;* agreeing with the experimental conclusion of Sir Robert Seppings, that the frame, with this disposition of the braces, "comes more in contact by the pressure."

Let us now endeavour to estimate the effect of a similar system of forces, on a system of framing, whose braces and trusses are disposed in *opposite* directions to those of the preceding investigation. For this purpose, let the first application of the lemma be to the longitudinal timber B C, and brace A C, fig. 2, A being the fulcrum, and let the point C be that to which the straining force is applied. Suppose C I to be its measure and direction, and

complete the parallelogram C *a* I *b*. Join *a b*, and through C draw *d e* parallel to that diagonal. Then, since the brace A C is on the *same* side of *d e* as the straining force, it will be subject to *compression*, contrary to the effect produced in the former case. But the longitudinal timber B C, like G H in the former figure, will undergo *extension*.

In the next place, let the straining force be supposed to be applied at E, in order to estimate its effects on the brace A C, and the truss F E, and let E K be its measure and direction. Complete the parallelogram E *f* K *g*, join *f g*, and draw *h i* parallel to it, through the point of application E. Then the brace A E being *below* the line *h i*, will undergo *compression* as before; and the truss F E being *above* the same line, will undergo *extension*.

In the third place, let the straining force be applied at D, to produce an effect on the brace B A, and the longitudinal piece D E, and let D L be its measure and direction. Complete the parallelogram of force D *k* L *l*. Join *k l*, and through D draw *m n* parallel to *k l*. In this case, therefore, the brace D A being *below* *m n* must undergo *compression*, and the longitudinal timber D E, being *above* the same line, must undergo *extension*.

Fourthly, let the straining force be applied at H, to estimate its effect on the truss E H, and the longitudinal timber G H, and let its measure and direction be H M. Complete the parallelogram of forces, H *o* M *p*, having its sides in the axes of the timbers proposed. Draw the diagonal *op*, and parallel to it, through H, the parallel line *q r*. Hence it appears, that the truss E H, being *above* the line *q r*, must undergo *extension;* and the longitudinal timber G H, being *below* the same timber, must undergo *compression*.

With this disposition of the timbers, therefore, it appears that the forces operating on the frame will produce *a compression of the braces* B A, C A, *and of the longitudinal timber*, G H; but on the remaining parts of the frame, viz., *the trusses* B D, D A, C E, E A, and the longitudinal timbers D E, B C, the effect will be to produce *compression*, agreeing also with the experimental con-

clusion of Sir Robert Seppings, that on the application of a straining force, the trusses and middle longitudinal piece will "be immediately disengaged and fall out."

The preceding results may be conveniently arranged in the following Table:—

	Nature of the Strain operating on the Timbers.				
	Braces.	Trusses.	Upper Longitudinal Piece.	Middle Longitudinal Piece.	Lower Longitudinal Piece.
With the Braces in the *fore body inclined aft*, and those in the *after body inclined forward*, as in figure 1.	EXTENSION	COMPRESSION	EXTENSION	COMPRESSION	COMPRESSION
With the Braces in the *fore body inclined forward*, and those in the *after body inclined aft*, as in fig. 2.	COMPRESSION	EXTENSION	EXTENSION	EXTENSION	COMPRESSION

The primary object of the diagonal framing is to prevent arching; and if we suppose AF in both figures to represent the neutral line from which the arching proceeds towards both extremities, it is evident that it is the mechanical combination represented in fig. 1 which can alone prevent it. For since A, in that figure, by the hypothesis, is one of the *neutral* points of the system, it may be regarded as fixed; and the tendency of arching being to depress the points H, C, and G, B, the effect on the braces A C and A B will be precisely similar to the weights applied in the preceding investigation; that is, to produce *extension*, and which is effectually provided for by the fastenings. The effect, moreover, brought at the same time into action by the trusses, in consequence of the disturbing force, is to resist, by the whole longitudinal strength of their fibres, all tendency to alteration of form; so that the effort exerted to depress the point C, is at once resisted by the fastenings appertaining to the brace A C, and to the

longitudinal strength of the fibres of the truss, proceeding from the unchangeable point F. The point E becoming, in this point of view, fixed, the action of the force which tends to depress the point H, in common with the point C, is resisted by the fastenings of the longitudinal timber A H, and by the longitudinal resistance of the fibres of the truss E H; so that, provided the fastenings of the braces and of the upper longitudinal timber are sufficient, and the abutments of the trusses and of the middle longitudinal timber are also proper, all tendency to arching will be resisted, in proportion to the perfection of the materials, and to the excellence of the workmanship.

But by referring to the converse disposition of the braces, as represented in fig. 2, it appears, from the preceding investigation, that the braces AC and AB are subject to *compression.* And since the point A is, by the hypothesis, the neutral or fixed point, the effect of the compression of the brace AC must be to *depress* the point C and thus to promote the tendency to arching. Nor is this tendency to lower the point C prevented by the action of the truss FE; since the point F being fixed by the supposition, the tendency to *extension* which takes place in the truss must tend to lower the point E, and thus to promote the further declension of the point C. The point E being thus depressed, must add its effect to the *extending* force called into action in the truss E H, and thus produce a declension in the point H. Hence the whole effect of the disturbing force is to *lower* every part of the frame from C to H, and thus to promote the arching of the vessel.

Hence the superiority of the present system of diagonal framing becomes apparent, and the advantages derived from it are demonstrated by the small alteration of form which ships now undergo in the act of launching.

Plymouth, May 26, 1826.

Art. IX. *Observations on Local and Electrical Influences on Compasses variously constructed; deduced from numerous Experiments, and necessary to be known in the Practice of Navigation. By* Edward John Johnson, Lieut. R.N. *(With a Plate.)*

[Communicated by the Author.]

As a circumstantial detail of the numerous experiments I have made on the magnetic needle at different meridians, might, in some cases, appear but a repetition of that which has already been accomplished, the object of the following paper is to communicate a few facts, the publicity of which may be useful in a practical point of view, accompanied by such remarks as the nature of the several cases seemed to require.

Until the nature of any phenomenon is thoroughly understood, the instruments employed for developing its effects must necessarily remain imperfect, for without this knowledge *à priori*, our assumptions are entirely arbitrary, as is the case with the construction of the compass, when considered relative to its capability of developing all the peculiarities of the magnetic phenomena; therefore it appears natural that endeavours should be made to expel or neutralize what may be considered irregular influences on the needle, either by the arrangement of artificial magnets on the compass card, or otherwise, for by progressive improvement in the instruments we can alone hope to approximate towards experimental results, which will stand the test of mathematical investigation or analytical scrutiny. Therefore the record of every trial which has been made at different meridians with compasses, differing from the ordinary construction of that instrument, it is presumed may not only be interesting but useful; for, however convenient it may be for experimenting, I cannot subscribe to the idea that the result produced by an artificial magnet or terrella is a sufficient proof of what the influence of the magnetism usually attributed to the terrestrial globe would be on a magnetic needle at certain positions on its surface, be-

cause the situation of the artificial magnet or terrella, with respect to the needle, must be so near, before the reciprocal effects of their respective virtues are decidedly developed over each other, as to render it necessary to take into consideration the effect of the substances from which such virtue emanates; and we have no proof that the phenomenon causing the directive power of the needle proceeds altogether from similar substances, and experiment clearly shews, that the magnetic virtue and the substance (in this instance steel) from which it emanates will sometimes act in unison, and sometimes contrary to each other on the needle; for the greatest effect which the virtue of an artificial magnet has over the horizontal direction of the needle, is when it is placed on the same horizontal plane with the needle, which effect decreases as it is elevated or depressed from that plane, while the contrary is the case with the simple substance, (*i. e.* steel and iron,) at certain altitudes, depressions, and bearings from the pivot. Hence when an artificial magnet is used to demonstrate magnetical influences on a needle freely suspended, the quantity, quality, and position of the ferruginous substances, from which the magnetic power proceeds, must be considered.

Having prepared three compasses on the principle delineated in Plate VI. fig. 2; viz., by placing two magnetic needles across each other at right angles, I found that they did not retain the same proportional direction from the meridians of Bywell, a village in the county of Northumberland, the latitude of which is 55° 1′ N., and longitude 1° 59′ W., and a position near St. Petersburgh, in latitude 59° 58′ 31′ N., and longitude 30° 19′ 45″ E., as that denoted by the ordinary compass-needle. The variation of the said ordinary magnetic needle was, in the month of June, 1824, ascertained by a set of azimuths, taken from the top of a church at Bywell, to be 26° 50′ W.

As the houses of the Russian metropolis are generally roofed with sheet-iron, I considered it necessary to make my observations at a distance from the town; and a friend, whose country-house was situated a league to the northward, obligingly afforded me that opportunity. The variation was ascertained by a set of

azimuths taken from his garden, under the most favourable circumstances, during some of those bright, calm, and cloudless days which gild the calendar of the northern summer. Their mean result gave the variation for August 1824, 7° 38′ W.; and the mean of a set of observations made by order of my lamented friend Professor Schubert, near the observatory in the capital, about the same time, gave the variation 7° 36′ W.

Taking, therefore, the variation at Bywell . .	26° 50′ W.
And that at St. Petersburg	7° 37′ W.
The difference of variation between the two meridians is	19° 23′

as ascertained by the ordinary magnetic needle; therefore any given point of compasses differently constructed, should, if they were acted equally upon by the general magnetic phenomenon and local influences, preserve a proportional difference from the two meridians; which, however, was not the case in this instance, as there was a discordance of 37 minutes in excess, making a total difference of 20 degrees between the two meridians, instead of 19° 23′.

Although it is usual to attribute the small discordances which occur in placing magnetic needles of various shapes alternately on a pivot, in a given position, to the imperfection of the instrument or the observer (and it must be allowed, from the circumscribed size of a magnetic needle, and the delicacy of its movements, on which the breath of the body, or a button, may effect a change, that there is extreme difficulty in avoiding all casualties), yet it appeared to me that there must be some more decided cause for the difference of 37 minutes before alluded to.

My first idea was, that it might have been produced by one of the needles being continually nearer to the magnetic meridian than the other, by which, if it were minimum, it might have had its magnetic powers augmented, or, if maximum, preserved; whereas no such effect would be produced on the other needle, which circumstance would alter the direction of the compass by the reciprocal influence which the needles first had over each other being changed. As the action of this compass seemed

vigorous, I considered the circumstance worthy of further investigation; and so far as miniature experiments may presume to mimic the great efforts of nature, the conclusion which I am enabled to draw from them is, that when needles of different shapes, or more than one is used, though they may be similarly, are not proportionally affected by all local and electrical influences, and especially those possessing magnetical properties, as might be anticipated. It is true that, in the experiments I made, the influences causing the deviation, on numerous compasses differently constructed (twenty-one of which are delineated in the accompanying figures), were near to the needle, such as steel and iron plates, in their simple and magnetized states, at various altitudes, depressions, and bearings from the pivot, the glass cover on which the electricity was excited, &c. Yet we cannot determine at all times when the needle is free from or under the influence of electricity, or ascertain the exact distance at which local influences commence or terminate; nor, when we *are* convinced that some local action is influencing the direction of the needle, can we separate and reduce to laws the forces which are casually acting upon it. Therefore it appears to me, that when observations are made for scientific applications with different needles, it is essential that they should be made of similar materials, and possess—

1. A similar magnetic power at any given place.

2. That they should be of the same shape, in order to have that power similarly disposed.

3. That they should be of the same size, weight, and temperament, in order to retain their virtue; and,

4. That the box, stand, and other parts of the apparatus, should be similar, that all influences might act equally upon them. In short, I consider, if it were possible to remove *the same instrument to different parts of the world*, without injuring any of its functions, more correct deductions might be made for scientific purposes. If these are principles already admitted by philosophers, it is nevertheless certain they are not always acted upon. It may not be unimportant to notice other conclusions which may be drawn

from these experiments, in many of which my object was to place an equal number of poles on opposite sides of the pivot or centre of motion, in such positions as to allow them to develop freely their respective attractive and repulsive energies; for although it is considered that every particle of a magnet possesses these properties, and in larger magnetic bodies that they succeed each other alternately throughout the mass, *yet space is necessary* to enable them to develop these energies; and with that idea they were placed in the several positions delineated in the figures, with a view to equalize all local, electrical, or terrestrial influences which might be acting casually and independently of the general directive power.

The experiments, however, proved that none of the arrangements of artificial magnets, described in the figures, would shield compasses so constructed from local influences; and as several years ago there was an experiment made to get rid of the local effect of ships, by placing the compass in an iron box, yet these results evince, that when the needle itself was enclosed in iron, without however touching it, or the iron having acquired permanent magnetism, yet the local influence of an iron plate on its horizontal direction was still apparent. Although I am not aware of any means by which a given quantity of electricity could be exactly elicited, yet a common experiment showed that none of the arrangements of artificial magnets before described did away with or equalized electrical effects; but there is one circumstance which I shall briefly notice; viz., that although the dip appeared very nearly neutralized by the arrangement of the magnets as described in figs. 20 and 21 (*i. e.* by using two magnetic needles, placing one on each side of the pivot or centre of motion, having balanced the two pieces of steel before the magnetic virtue was communicated), yet the local influence of the iron continued to be similarly developed on a compass so constructed. This may be termed counteracting the dip by artificial means; but it must be remembered that there is no additional weight or incumbrance attached, but merely the phenomenon itself acting naturally upon the two needles. How far

such a compass would be useful in high latitudes, I shall not at present venture to anticipate; but although it is evident that, in the first instance, its power would be weakened by the space of separation of the needles, yet it remains to be proved whether that circumstance would not be compensated for by the neutralization of the dip, and the constant excitation which would be kept up between the two needles by the poles of opposite names being nearest to each other. This remark may seem to be at variance with the generally-received opinion of magnetical action; but the proposition is simply to use two magnetic needles without incumbrance, instead of one with it; not presuming, however, on the certainty of a beneficial result in high latitudes, but merely a suggestion for experiment.

The next circumstance which I shall proceed to notice, and which is intimately connected with the former part of these remarks, is, that the local effects of certain substances on the magnetic needle are totally changed when under the influence of electricity, which is so frequently and inadvertently excited; and as the safety of ships, in the ordinary course of navigation, frequently depends on the correctness of bearings, and as the very act which commonly precedes these observations, with an idea of caution and correctness, and which I have often witnessed, is the means to produce error, the relation of the following fact may serve as a caution to those who are in the habit of trusting to magnetical bearings, as well as in the use of theodolites and other instruments which have magnetic needles attached to them.

Whether or not it is the solar rays which are partly absorbed in their passage through pellucid substances, which impart to them luminous matter, that may be excited, it is not my present object to inquire; and although it is known that electricity may be excited by friction on glass, yet I am not aware that it has ever been shewn that the simple circumstance which I am about to notice may cause such serious errors in a practical point of view.

Having observed a considerable deviation produced on the

needle by the mere act of wiping the dust from the glass cover of the compass-box with a silk handkerchief, I rubbed it successively with silk, woollen, cotton, and linen, and found that they produced similar results, and also leather in a less degree, *viz.*, causing a considerable deviation, generally to the eastward; sometimes as much as 20°, and once to 40°, from the magnetic meridian; and this, whether the friction was performed circularly or longitudinally, the said silk, linen, woollen, and cotton, having acquired the power of repelling both poles of the needle when held near the glass cover; and on placing various substances in the same position with respect to the needle, such as minerals, precious stones, metallic ores, wood, bone, gold, silver, copper, brass, lead, and iron, a similar effect, *viz.*, that of repulsion, was exhibited, so that in this case, not only what is considered the terrestrial magnetism, but also the natural effect of the iron itself was overcome. An artificial magnet alone seemed to retain its respective, though not its proportional, powers over the needle.

By removing the glass cover and rubbing it, and then placing it again over the needle, I found it produced similar results; but on approaching any of the substances before-mentioned, near to the needle, immediately on removing the cover, I could not detect any other than the effects which might be anticipated from the nature of the simple substances, such as the known effect of iron, &c.

In many instances, one pole of the needle adhered for more than a minute to the glass cover, and then gradually losing such power, it declined again to its horizontal and directive positions; but as it required a space of time to acquire its natural functions, or rather to get rid of the electrical power, and as several observations might be made in such an interval, as a caution to observers in general, the deviation produced by such a slight circumstance as before alluded to is here inserted, and also the time of the needle's return to the magnetic meridian.

The following results were noted at Bywell, in two successive days in January, 1826:—

Time when the Glass cover was rubbed.	Deviation produced by that circumstance.	Time at which the Needle returned to the magnetic meridian.	Interval.
H. ′ 1 20 P.M.	° ′ 12 0 Easterly	H. ′ 1 30 P.M.	H. ′ 0 10

Time when the Glass Cover was rubbed, and the intervals of the Needle's approach to the Magnetic Meridian.	Deviation * produced by that circumstance, and its gradual approach to the Magnetic Meridian.	Total interval of time elapsed from the Glass Cover being rubbed, to the Needle's return to the Magnetic Merid.
H. ′ 10 22 A.M.	° ′ 14 0 Easterly	H. ′ 0 53
10 50 A.M.	2 30 ditto	
10 58 A.M.	1 30 ditto	
11 15 A.M.	0 00	

As every species of matter is considered to be susceptible of electricity, and that the air immediately environing an electric body becomes similarly electrified, as also bodies when brought very near; and as it is known that substances possessed of the same sort of electricity repel each other, perhaps the simplest way of accounting for the repulsion exhibited between the needle and those already mentioned, is to consider them as becoming similarly electrified, by being brought very near to the electrified body; but as one sort of electricity cannot exist without the other, and as substances in their natural state, being placed at a distance, but within the sphere of action of an electrified body, become dissimilarly electrified, so it is probable, that when the effects can be properly developed, attraction between a magnetic needle, under the influence of the electric virtue, and substances at certain distances within its sphere of action, would be exhibited.

It appears, however, that the effect of the nearest substances is more particularly to be considered in this case (hence the conclusion which I have drawn respecting the box, stand, *&c.*, on which the needle is placed); and as those which are pellucid, such as glass, amber, resins, *&c.*, are known to be capable of confining

* It may be necessary to state, that in order to observe the deviation more exactly, there was a small talk vernier, or nonius, attached to the needle, which may have aided in detaining the needle longer from the magnetic meridian, by means of its greater capability of retaining electricity.

and retaining the electric virtue; and as it is not excited by friction alone, but by contact, and possibly by the mutual action of two bodies at a distance, so it is not possible always to ascertain when it is or is not acting upon the needle; nevertheless it may be inferred that the covers of compasses made of such materials, where it is possible, are better dispensed with, when the observations are intended for scientific purposes.

EDWARD J. JOHNSON.

ART. X. *Improvements in the Solution of Equations by Continued Fractions.* *By* W. G. Horner, Esq.

[Communicated by the Author.]

II.

14. In the preceding part of this investigation, my object has been to shew in a familiar manner, that, throughout the continuous portion of Lagrange's process of solution, $\frac{-\pi}{\rho}$ is more nearly the average value of each inferior root, than $\frac{-\pi'}{\rho'}$, adopted by that author; and that a considerable augmentation of approximative power, as well as a clearer view of the general subject, is gained by attending to this distinction. If these conclusions be correct, it is worth while to examine whether a manageable expression for the *real average* of those roots cannot be attained, since it is probable that with such aid the solution may be carried to the utmost point of accuracy.

The average in question must be a function of both the fractions we have named, since each of the roots in question is so. For having generally $x = \frac{\pi + \varrho t}{\pi' + \varrho' t}$ and therefore $t \doteq \frac{\pi' x - \pi}{\rho - \rho' x}$, any subordinate root t' will be $\doteq \frac{\pi' x' - \pi}{\varrho - \varrho' x'}$; or rather $- \frac{\pi - \pi' x'}{\varrho - \varrho' x'}$, in a form which has more symmetry, and reminds us of the negative character of these roots in their efficient state.

15. Now the average of any number of quantities of the form

$\frac{\beta + \alpha y}{\beta' + \alpha' y}$, where $\frac{\alpha}{\alpha'}$, $\frac{\beta}{\beta'}$, are consecutive converging fractions, may always be determined in a similar form, *viz.* $\frac{\beta + \alpha z}{\beta' + \alpha' z}$.

This will plainly appear, if we remark that the sum of $\frac{\beta}{\beta'}$ and any quantity q, may be represented by $\frac{\beta + \alpha z}{\beta' + \alpha' z}$. For by equalizing these, we obtain $z = \frac{\mp \beta'^2 q}{1 \pm \alpha' \beta' q}$.

All that is requisite, therefore, is to resolve each of the quantities $\frac{\beta + \alpha y}{\beta' + \alpha' y}$ into the form $\frac{\beta}{\beta'} + q'$, and then to substitute for q in the above value of z, the sum of all the quantities q'.

16. To apply this to the present purpose; since $-t' = \frac{\pi - \pi' x'}{\rho - \varrho' x'}$ $= \frac{\pi'}{\varrho'} \mp \frac{1}{\varrho'(\varrho - \varrho' x')} = \frac{\pi'}{\varrho'} \mp \frac{1}{\varrho'^2}\left(\frac{1}{\frac{\varrho}{\varrho'} - x'}\right)$, from which $-t''$, $-t'''$, &c., vary, only in containing x'', x''', &c. for x'; and since the sum of the reciprocals of $x - x'$, $x - x''$, ... $x - x^M$ is $\frac{dX'}{X'dx}$ by the theory of equations, if $X' = (x - x')(x - x'')\ldots(x - x^M)$; it follows that

$$-(t' + t'' + \ldots t^M) = \frac{m\pi'}{\rho'} \mp \frac{dX'}{\varrho'^2 X' dx}, \ldots\ldots\ldots (1)$$

if x after differentiating is changed into $\frac{\varrho}{\varrho'}$.

But if $\frac{\pi + \pi' f}{\varrho + \varrho' f}$ be put for the average of the roots, $-t'$, $-t''$ &c., we have $-(t' + t'' + \ldots t^M) = \frac{m(\pi + \pi' f)}{\varrho + \varrho' f}$, which, by Art. 15, is $= \frac{m\pi'}{\varrho'}$ $\mp \frac{m}{\rho'(\varrho + \varrho' f)} \ldots\ldots\ldots (2)$.

By equalizing (1) and (2) we have $\frac{m}{\varrho + \varrho' f} = \frac{dX'}{\varrho' X' dx}$, which gives $f = \frac{mX'dx}{dX'} - \frac{\varrho}{\varrho'}$, if x after differentiating is changed into $\frac{\varrho}{\varrho'}$.

Assume therefore $X' = x^m + A'x^{m-1} + B'x^{m-2} + \ldots . K'$, an equation involving any m, out of the $n - 1$ subordinate roots, and we obtain

$$f = \frac{A'\varrho^{m-1} + 2B'\varrho^{m-2}\varrho' + 3C'\varrho^{m-3}\rho'^2 + \ldots\ldots mK'\varrho'^{m-1}}{m\varrho^{m-1} + (m-1)A'\varrho^{m-2}\varrho' + (m-2)B'\rho^{m-3}\varrho'^2 + \ldots . H'\varrho'^{m-1}}$$

By the aid then of this function we can express the accurate value of the average of those m roots. Q. E. I.

17. The relation in which this quantity stands to others engaged in the solution will be more apparent, if the formula which expresses the average root (see above) be reduced to a continued fraction. This will be effected by the process for reducing $\frac{\pi'}{\varrho'}$ to such a form. For the same operation reduces $\frac{\pi}{\rho}$, by an equal gradation, and terminates when ϱ has fallen back to its initial value, say p; at which time the other quantities have become $\pi = 1$, $\rho' = 1$, $\pi' = 0$. So that $\frac{\pi + \pi' f}{\varrho + \varrho' f}$ will have become $\frac{1}{p+f}$. Or, its value as a continued fraction is the same as that of $\frac{\pi}{\varrho}$, if f be added to the denominator p.

Connecting this statement with that of Art. 8, we shall see that if $\frac{\rho}{\rho'} = p + \frac{1}{p_1} + \frac{1}{p_2} + \ldots . \frac{1}{p_r}$, the continued fraction equivalent to the average root $\frac{\pi + \pi' f}{\rho + \rho' f}$ will be $\frac{1}{p_r} + \frac{1}{p_{r-1}} + \ldots . \frac{1}{p_1} + \frac{1}{p} + f$.

18. Now as this fraction gives the value either of $\frac{\pi'}{\rho'}$ or $\frac{\pi}{\rho}$, according as it is broken off at p' or p (Art. 8), it is manifest that these fractions are limits to the average root when f is affirmative. This occurrence therefore, as far as the m roots in question are influential, is a criterion of the continuous stage of solution (Art. 7.) The same conclusion might also be drawn from applying the limits $f > 0 < \infty$ in the simple fraction.

19. Any other than a brief and cursory glance at the relations of f when negative, would be irrelevant to the present subject. It

will be sufficient to remark that when $-f$ is nearly $= \frac{\varrho}{\rho'}$, or to any of the fractions converging to it, we shall find a greater or less number of the converging quantities $\varphi_1 = \frac{1}{p+f}$, $\varphi_2 = \frac{1}{p_1+\varphi_1}$, &c. become also negative. This circumstance therefore marks the existence of a second root nearly equal to that which is in course of evolution, or of a pair of imaginary roots whose real part is nearly equal to the said root, while their impossible part is very minute *.

The cases in which $-f$ is either $> p + 1$ or $< p$, can defer the continuous process only by a single step; and it may be said to commence with the latter case; since though $\frac{\pi'}{\rho'}$ and $\frac{\pi}{\varrho}$ at that time are both on the same side of the average root, either of them is a good approximation toward it. (Art. 7).

20. Now f is affirmative, when $mX' > \frac{xdX'}{dx}$; which will manifestly be the case when X' has every term affirmative. But the same facility may exist without this condition, and especially through the intervention of imaginary roots. For, let $x', x'' = u \pm v\sqrt{-1}$ be a pair of such roots; then will $A' = -(x' + x'') = -2u$ and $B' = x'x'' = u^2 + v^2$; whence $f = \frac{-u\varrho + (u^2+v^2)\rho'}{\rho - u\varrho'}$ $= -u + \frac{v^2}{\frac{\rho}{\varrho'} - u}$ which may manifestly be affirmative, even when u is affirmative, and A' consequently negative.

* The extreme improbability of such a relation occurring incidentally among the sought and imaginary roots, will be apparent from the form of f in the next article. But an explicit statement will possibly render it more striking. If $x = \frac{\pi + \rho t}{\pi' + \rho' t} = p + \frac{1}{p + \ldots\ldots p_\tau + t}$ be entangled to this extent with the development of $u \pm v\sqrt{-1}$, put $U \pm V\sqrt{-1}$ for the value of the latter in the next transformation, and we have

$$u = p + \frac{1}{p_1 + \ldots\ldots p_\tau + U + \frac{V^2}{U} + p_\tau + p_{\tau-1} + \ldots\ldots p_1}$$

for the rational part of each of the imaginary roots; where the double effect of every denominator is remarkable.

21. Leaving these general and hypothetical remarks, we proceed to the principal subject of inquiry, the average of all the inferior roots. Here m being $= n - 1$, the expression for f becomes

$$F_x = \frac{A'\rho^{n-2} + 2B'\varrho^{n-3}\varrho' + 3C'\rho^{n-4}\varrho'^2 + \ldots\ldots(n-1)K'\rho'^{n-2}}{(n-1)\rho^{n-2} + (n-2)A'\rho^{n-3}\rho' + \ldots\ldots H'\rho'^{n-2}}$$

where A', B', C', &c. are readily definable in terms of x. For, supposing the original equation to be

$$X = x^n + Ax^{n-1} + Bx^{n-2} + Cx^{n-3} + \ldots . L = 0,$$

and putting R for that which X becomes, when $r = \frac{\varrho}{\rho'}$ is substituted for x, we have X', in this instance, $= \frac{R}{r-x} = \frac{R-X}{r-x}$.

Hence we find $A' = x + A - \frac{hX}{x^{n-1}}$, $B' = A'x + B$, $C' = B'x + C$, &c.

The arbitrary term annexed to the value of A' is evanescent while x remains; but may be so employed as to render the approximation closer when $\frac{\rho}{\rho'}$ is substituted for x, as it must ultimately be. Indeed, since $h = 0$ gives A', B', &c. all in affirmative powers of x, and $h = 1$ gives them all in negative powers, or powers of $\frac{1}{x}$, where the errors from taking $\frac{\varrho}{\rho'}$ for x are all of a contrary affection to what happens on the former assumption, we may conclude that there is some value of $h > 0 < 1$ in which the errors are so balanced, as to neutralize the error on the whole. This point is left open for future research.

It may however be remarked, that since $h = 0$ excludes L, and $h = 1$ excludes A, the effect required may, in a useful degree, be gained by excluding some intermediate coefficient, which the equation $x = 0$ always furnishes the means of doing. Thus, if

$$X = x + A'x^2 + Bx + C = 0$$

we shall better satisfy

$$X' = x^2 + A'x + B'$$

by making $A' = x + A$ and $B' = \frac{-C}{x}$, than by making the latter $= x^2 + Ax + B$, though, while x remains, the two are equivalent.

22. If the arbitrary term be neglected, the general value of F_r may be found most neatly thus.

Since $X' = \frac{R - X}{r - x}$, and after division, x is to be changed to r,

we have $X' = \frac{d(R - X)}{d(r - x)} = \frac{dX}{dx}$ changing afterwards x to r.

But $dX = \frac{(R - X)\,dx - (r - x)\,dX}{(r - x)^2}$, which on the same principle

is found $= \frac{d^2X}{2dx}$. Hence

$$F_r = \frac{(n-1)dXdx}{\frac{1}{2}\,d^2X} - \frac{\rho}{\rho'}$$

if x is ultimately changed to $\frac{\varrho}{\varrho'}$, that is

$$F_r = \frac{\frac{1}{2}(n-1)n\varrho^{n-1} + \frac{1}{2}n(n-1)A\varrho^{n-2}\rho' + \frac{1}{2}(n+1)(n-2)B\rho^{n-3}\varrho'^2 + \ldots\ldots\ldots\ (n-1)K\rho'^{n-1}}{\frac{1}{2}n(n-1)\varrho^{n-2}\rho' + \frac{1}{2}(n-1)(n-2)A\rho^{n-3}\rho'^2 + \frac{1}{2}(n-2)(n-3)B\varrho^{n-4}\varrho'^3 + \ldots\ldots\ldots\ H\varrho'^{n-1}}$$

which, as we have shewn, may be rendered yet more accurate by introducing the absent term L by means of the original equation. For example, by adding $(n-1)(K' - K') = (n-1)\left(\frac{L}{x} - x^{n-1} - Ax^{n-2} - \ldots\ldots - K\right)$ and restoring $\frac{\rho}{\varrho'}$ for x, we have for a corrected numerator of F_r,

$$\frac{1}{2}(n-2)(n-1)\rho^{n-1} + \frac{1}{2}(n-1)(n-2)A\rho^{n-2}\rho' + \frac{1}{2}(n.n-3)B\varrho^{n-3}\varrho'^2 + \ldots\ldots \frac{L\varrho'^n}{\varrho}.$$

23. The correct value of t (Arts. 2, 9) is now ascertained to be

$$t_x = a + \frac{(n-1)(\pi + \pi' F_x)}{\rho + \rho' F_x};$$ which differs from

$t_r = a + \dfrac{(n-1)(\pi + \pi' F_r)}{\rho + \rho' F_r}$ the nearest value which we have the means of attaining, by

$$t_x \backsim t_r = \frac{(n-1)(F_x \backsim F_r)}{(\varrho + \rho' F_x)(\rho + \rho' F_r)} \dots\dots\dots\dots\dots\dots (E_1)$$

and from Lagrange's assumption for t, by

$$\frac{(n-1)}{\varrho'(\varrho + \rho' F_x)} \dots\dots\dots\dots\dots\dots (E_2)$$

The former error is less than the latter, when

$$F_x \backsim F_r < \frac{\rho}{\varrho'} + F_r$$

that is, when either $F_x < F_r$, or $F_x < \dfrac{\rho}{\varrho'} + 2F_r$, conditions which we have means of securing, at the first step of the continuous process, and which are sure to obtain ever afterwards.

The question of limits is therefore reduced to finding whether, as soon as F_x is > 0, we have also $E_1 < \dfrac{1}{2}$.

24. With regard to the subsequent process of the solution, it may be sufficient to observe, that if the least effective value of F_r be introduced for F_x in E_2, the latter becomes equivalent to Halley's improvement on Newton's method of solution, which is known to double the correctness of the approximation. Hence it may be concluded that the value of t will be found by the method now described, to twice the extent obtained in the former part of this paper; and, consequently, that of x to an extent *three times* as great as was contemplated by Lagrange.

Of this the reader may satisfy himself by resuming the example in Art. 10. But as a general example will be more useful, I intend to devote a sheet to the solution of the binomial formula $x^n - L$, for the sake of elucidating the principles here laid down.

In equations of high dimensions, it may be convenient to aggregate the continued fraction at every step, and proceed as in § 82 of *Res. des Eqq. Num.* which will be rendered correct by substituting $R - E_2\rho'$ for R.

Schol. It is much to be regretted, that the function here denoted by F_x did not occur to Lagrange himself, in whose able hands it might have assumed its whole efficacy in his general system. Some one more favoured in regard of leisure and ability than I am, may yet take up and complete the subject. Besides the purposes to which it is applied in this paper, I have observed that the whole of our author's critique on Newton's method of approximation, (*Res. des Eqq. Num.* Note V.) may be superseded by the single remark that $\frac{1}{a}$, Newton's first correction of the assumed root p, is trustworthy, whenever $p, p + \frac{1}{a}, p + \cfrac{1}{a + \cfrac{n-1}{p + F_x}}$ are convergent. The last of these formulæ, according to what I have just stated, is equivalent to Halley's method, if F_x is valued by the least effective formula for F_r.

Art. XI.—*Statement respecting a Passage in* Mr. Daniell's *Paper on the Barometer, published in the Twentieth Volume of the Quarterly Journal of Science and the Arts. By one of the* Editors; *together with a Letter from* Mr. Daniell *upon the same Subject.*

At a council of the Royal Society, held on the 26th of January last, I was informed by one of the members, that a mistatement had appeared in this *Journal*, respecting the transactions of the Council of the Royal Society, and that the proceedings of that body had been improperly divulged in a publication of which he believed I was editor: it was further asked, whether it was my intention to offer any explanation upon the subject. I replied, that any explanation of the supposed mistatement which I could offer, and which the Council wished for, should appear in the ensuing number of the *Journal*: to which it was rejoined, that nothing was wished or suggested on the subject; but that the whole was left to

my discretion. Sincerely conceiving it for the benefit of all parties that the discussion should drop, and finding others of the Council of the same opinion, I resolved to take no further notice of what had passed; and hoped, for reasons which will appear, that the matter would not again have been agitated, when a question was put to me, at a council held on the 25th of May, whether any explanation of the said misrepresentations had been offered? The subject is therefore most unwillingly thrust upon me, and I must explain the alleged mistatement, and contradict the insinuation of having been instrumental in an improper disclosure of the transactions of the Council; and also call upon Mr. Daniell for such remarks as he may think right to offer.

It may be necessary to premise, that I was requested by Mr. Daniell to suffer no further postponement of the Council's determination respecting his paper, as it had already been several months before them; but that if any proposal were made to that effect, to withdraw it, and immediately publish it in this *Journal.* This I distinctly stated to the Council as a ground which would prevent my voting for or against its publication, and I accordingly declined balloting upon the question.

The following is the passage of Mr. Daniell's paper, containing the ground of accusation.

" The paper was again laid before the council just before the recess, when, on account of a division of opinion, their determination was postponed to next year. A member of the council then asked leave to withdraw the paper, in order to allow of its publication elsewhere, and stated that I had neglected to preserve a copy of the manuscript. *The president, I am told, objected to this, and* LAID DOWN THE LAW, *that the paper, having been once taken into consideration by the council, could not be withdrawn.*"

It is said that Mr. Daniell had no business to know what passed on this occasion, and that the president laid down no law upon the subject; that *therefore* the proceedings of the council have been improperly divulged, and that the paragraph insinuates an untruth. Although no gentleman would repeat, for any sinister purposes, what passes in what may be called a private committee,

yet I never heard of the Council being sworn to secrecy; and although it so happens that Mr. Daniell did not get his information from me, let us suppose, if we had met after the said council, what our conversation would probably have been. He would have asked whether the fate of his paper had been decided. Upon my reply in the negative, he would have inquired whether I had then withdrawn it; to which I should have rejoined, "No: the number of balls for and against printing it being (in consequence of my declining to ballot) equal, the president referred to the bye-laws, and there found that, under such circumstances, the consideration of the paper must be referred to the next council." This council, in consequence of the vacation, was not held for some months. I was, however, not allowed to withdraw the paper, and it was consequently withheld from the public.

After all, therefore, the secret divulged amounts to Mr. Daniell's having been informed why his paper was not decided upon; and the alleged misrepresentation consists in Mr. Daniell having used the expression of laying down the law, in reference to the president having searched the by-laws, and there found a law which he laid down as applicable to the case before the council. It has, however, been conceived that some persons might imagine that the president had at the moment framed the law, and insisted upon its being acted on by the council. But, to say nothing of the improbability of the president acting thus, and of the council being so guided, the term *laying down the law*, in the sense used by Mr. Daniell, is in such common use as amply to exonerate him from the imputation of wilful misrepresentation.

I hope that what passed upon the above occasion is now rendered perfectly intelligible. At the same time, as one of the Editors of this Journal, I protest against being held responsible, upon similar occasions, as the public interpreter of all expressions which gentlemen may choose to employ in the communications they are kind enough to send to this work.

William Thomas Brande.

Letter from Mr. Daniell.

Gower-street, June 14, 1826.

Dear Sir,

I BEG to return you my best acknowledgments for communicating to me your explanation of a passage in my paper upon the barometer, which has been called for by the council of the Royal Society; and I cannot but reiterate my regret, that you should have been troubled upon a subject with which, as it appears to me, I alone am concerned. Considering that I am not only a Fellow of the Society, but that I was, at the time when the alleged mistatement was put forth, a Member of the Meteorological Committee, it does appear to me, that it would have been at once more just, dignified, and satisfactory, to have demanded an explanation of any misunderstanding of *me*, in my place, than summarily to have excluded me from the committee, and to have required the explanation of *you*. However, *de gustibus non est disputandum;* and I shall now endeavour to render, if possible, more intelligible what it requires all the evidence before me to convince me could ever have been mistaken. As this is the last time that I shall ever voluntarily refer to disputes which seem to me to be little calculated to "promote natural knowledge," or advance the "dignity of science," I shall take the liberty of making my explanation, thus forced from me, full and complete.

When first I had the honour of being elected into the Royal Society, I was naturally anxious to promote its objects to the utmost of my humble abilities, and to prove, if possible, that I was not wholly unworthy of the distinction conferred upon me; I, therefore, shortly afterwards, presented to their consideration my paper upon Crystallization, which was subsequently published in the first number of the *Journal of the Royal Institution.* This paper went through the usual processes of public perusal, and subsequent reference to committees and sub-committees of the council; from whose decision, after various explanations, I was persuaded to withdraw it, upon the alternative of having it

handed to the archives. As the paper was accompanied with some expensive drawings, for copies of which, according to the privilege in such cases allowed, it did not suit me to pay, I acquiesced, though with much reluctance, in the suggestion. The insight afforded me upon this occasion into the manner of judging of the merits of a communication, did not make me in love with the jurisdiction; and I determined, as I presume I had a right to do, never to submit to it again. Upon this subject I shall not consider it worth while to say more, unless again called upon to explain.

My determination I kept for many years, till being repeatedly solicited by Sir H. Davy, shortly after his elevation to the presidentship, to communicate my papers to the society, I thought that it would be invidious to refuse, and accordingly acceded to his wish, that I should become a member of a committee of meteorology, with a full intention of doing my utmost to promote an object, of the utility of which I was fully impressed. My first paper after this, as I have elsewhere stated, was handed to the archives without even the form of a perusal! My second I was not permitted, according to the usual courtesy of the society, to withdraw from impending fate!! and my third, which appears in this number of the Journal, was black-balled!!! according to report, for the council of the society have not thought it worth while to communicate its decision in the usual way.

Now for my explanation of the portentous words, "THE PRESIDENT LAID DOWN THE LAW."

I do hereby declare, that I did not use the said words in a literal sense, as implying that the president did, with all due solemnities of his mace and seal, enact a law, and cause the same to be entered with all proper forms of registry in the code of the by-laws of the Royal Society, but that I did use the same in a figurative or metaphorical sense, meaning thereby that, whereas there exists in most civilized institutions a certain degree of courtesy amongst the members, the rules of which are not unfrequently, but figuratively, styled the laws of courtesy; and whereas it has always been the law of courtesy (so figuratively

speaking) with the council of the Royal Society, to allow of any paper being withdrawn from their jurisdiction previously to its merits having been finally determined upon by them (to the contrary of which I do defy them to produce any precedent), and whereas I did make application so to withdraw my paper under the old law of courtesy, having the fear of black balls before my eyes, the president (figuratively speaking) laid down a new law of courtesy; or, perhaps, more accurately, enacted a new law of discourtesy towards me; and, of course with the concurrence of the rest of the council, refused my most humble application: putting me thereby to the necessity of re-writing my paper (a trouble which I do abominate), and subjecting the unhappy offspring of my brain to the necessity of the scientific ostracism.

I trust, my dear Sir, with the assistance of *variorum notes*, that my meaning will now be perfectly intelligible; but if there be still any latent obscurity, I cannot but hope that you will not be held responsible for it; as, with regard to what is past, I shall always hold myself ready to explain; and with regard to the future, I shall take care that no such explanation will ever be required. I remain, dear Sir, yours, faithfully,

J. F. Daniell.

To W. T. Brande, Esq., &c. &c. &c.

Art. XII.—*Observations on the State of Education in Ireland, by* George Harvey, F.R.S.L. *&* E., F.G.S., *&c.*

[In a letter to the Editor.]

Sir,

Since the publication of my paper on the state of Education in Ireland, in the 38th number of your *Journal*, another return has been made to the House of Commons on this deeply interesting subject; and as I purpose recurring to its consideration, as often as new materials are afforded, I shall make the return in question the subject of my present communication.

In the paper referred to, I had occasion to lament the uncertainty which appeared to hang over the numerical estimates of the children enjoying the advantages of education; but in the return, on which I purpose to ground my present remarks, much of that uncertainty is removed; and I rejoice in being able to lay before your readers conclusions more cheering than before, but still tinctured with *very many* regrets.

To obtain the necessary returns, the Commissioners of Education Inquiry adopted a plan most unexceptionable and proper, by requiring from the Protestant and Roman Catholic clergy *separate* "accounts of the number of schools in Ireland, and of the scholars in attendance therein, and distinguishing the religion of the scholars;" and when I add that the two returns agree *precisely in the number of schools*, and *nearly so in the number of scholars*, I feel disposed to regard them as exhibiting a faithful statement of the state of education in Ireland during the year 1824.

The results of this very interesting inquiry are entered in the following table:—

	Number of Schools.	SCHOLARS, Distinguishing their Religion.					Total.
		Of the Established Church.	Presbyterians.	Other Denominations.	Roman Catholics.	Religion not stated.	
Protestant Returns	11,843	93,429	45,277	3,402	408,065	10,093	560,266
Roman Catholic Returns	11,843	92,098	44,471	3,675	421,415	7,414	569,073

Adopting, therefore, the number of children returned by the Roman Catholic clergy, as the number educated, and which I feel disposed to do, because the great bulk of the population being catholic, it is reasonable to suppose that the order of men which presides over the spiritual destinies of the majority of the people must be best acquainted with at least their numerical condition.

It will, nevertheless, appear, that education is by no means so widely diffused in Ireland, as the warm and sanguine lovers of human improvement could desire.

In my former paper I endeavoured to estimate the state of education, by comparing the pupils enumerated, both with the children *actually existing* from five to ten years of age, and from five to fifteen,—the latter being most probably the limits between which the majority of the scholars must be found. Adopting, therefore, the population returns of Ireland for 1821, we shall find there were 920,757 children between the ages of five and ten; and between the ages of five and fifteen, 1,748,663. If either of these results be compared with the numbers actually educating, there can only arise from the comparison feelings of the deepest sorrow and regret: for, according to the education returns, there are 569,073 children receiving the advantages of instruction; and if we suppose the scholars to be confined to the ages between five and ten, there must be 351,684 children totally deprived of its benefits: or, if we suppose the pupils to be confined to the ages between five and fifteen, there must at the present time be 1,179,590 children* immersed in all the horrors of ignorance. Would the condition of England be what it is, if half or two-thirds of its adult population were deprived of the blessings of education, shut out from the light of knowledge, and the cultivation and exercise of those duties which so much tend to humanize and improve mankind?

There has been another account obtained by the commissioners of education, and inserted in the same parliamentary return, "of the number of children educated in schools not receiving public aid," and which it may be interesting to some of your readers to have recorded here:—

* The population of Ireland is without doubt increasing, but at what rate cannot with accuracy be ascertained. The education returns referred to in the text are for 1824, and those of the population for 1821, and the two, therefore, cannot be strictly compared. Still, as the population is increasing, any error that may arise from the augmentation of the two classes referred to, in the interval from 1821 to 1824, must operate in favour of the argument.

	Number of Schools.	Of the Established Church.	Presbyterian.	Of other Denominations.	Roman Catholics.	Religion not stated.	Total.
Protestant Returns.							
Total number of Children educating in Ireland . .	11843	93429	45277	3402	408065	10093	560266
Deduct number of Children educating in Schools receiving public aid . . .	1108	26025	9386	443	31058	2274	69186
Remaining number of Scholars educated in Schools not receiving public aid . .	10735	67404	35891	2959	377007	7819	491080
Roman Catholic Returns.							
Total number of Children educating in Ireland . . .	11843	90098	44471	3675	421415	7414	569073
Deduct number of Children educating in Schools receiving public aid	1108	26040	9216	496	31677	1240	68669
Remaining number of Scholars educated in Schools not receiving public aid . .	10735	66058	35255	3179	389738	6174	500404

Plymouth, May 21, 1826.

Art. XIII.—*Experiments on the Incinerated Ashes of Calicoes, dyed by the Adrianople, or Turkey-red Process. By* Andrew Ure, M.D., F.R.S., &c.

[Communicated by the Author.]

The experiments detailed in the former part of this paper *, shew that the ashes procured from the combustion in open vessels of different pieces of white calico, merely washed, differ remark-

* *Quarterly Journal of Science*, xxi. 28.

ably from each other in chemical composition. One piece of well-dried cloth afforded, out of 1000 parts by weight, 4.2 of a residuum, which, when pulverized, afforded to boiling water no appreciable quantity of soluble matter. Another piece yielded from 1000 parts only 1.6 of ashes, being about one-third of the above proportion; but of these ashes fully one-third part was soluble matter, chiefly carbonate of potash. One thousand grains of another piece left 3.3 grains of ashes, one-half of which was soluble matter, being nearly pure carbonate of potash.

I found that 1000 grains of clean cotton wool yielded, on an average, 9½ grains of incinerated matter, of which nearly two-thirds was soluble saline matter, containing a predominance of carbonate of potash. It would appear from these results, that cotton cloth, by being well washed, and then boiled in a weak alkaline water, to clear away the weaver's dressing, may lose a considerable portion of its fixed or incombustible constituents; but that this portion is variable, both as to quantity and nature. Possibly cottons growing in different soils and climates differ in composition, as they do in the texture of their fibres. But if the above-described diversities of composition can be produced during the mere scouring of the calico to free it from the fermented flour paste, we may expect still greater changes of composition to occur, during the varied and fatiguing operations to which the cloth is subjected in receiving the Turkey-red dye. It deserves to be remarked, that the ashes of such calicoes contain no appreciable quantity of alkaline matter, notwithstanding the numerous soda steeps in which the cloth had been immersed; whereas cotton fibre itself furnishes ashes rich in alkali. Indeed, the entire absence of soluble matter, in the ashes of the first piece of white calico, struck me so much, that I was led to conclude that piece of goods to have been bleached after an unsuccessful dyeing operation, as is occasionally practised; by which alternate processes, the vegetable fibres had been stripped of their alkaline constituents. On mentioning this conjecture to the conductor of the extensive dye-works from whence I had received the cloth, he admitted its probability, though he could not ascertain its truth.

My views, thenceforth, were chiefly directed to the proportion of alumina, which I could detect in the dyed calicoes. In this respect it became necessary to be on my guard against one source of fallacy, which became very obvious to me in the researches on the white cloth ashes. Though phosphate of lime, when digested in a watery solution of pure potash, is neither decomposed nor dissolved, yet when that calcareous salt is ignited in contact with caustic alkali in a silver basin, a partial change is produced, indicating a combination; so that water digested on the fused mass, takes up a portion of the phosphate of lime along with the alkali, which pass together through the filters. Likewise, when alumina exists in small quantity, mixed with phosphate of lime, the action of caustic alkali, even at a red heat, seems incapable of dissolving out at one operation the whole of the alumina, so as to render it soluble in water. Hence considerable difficulties occurred in the examination of the incinerated matter of the Turkey-red cloths, which a person could not well have anticipated.

A piece of full-dyed Turkey-red cloth (about 12 yards long) weighing 7885 grains, in a perfectly dry state, yielded of well-ignited ashes 92.65 grains, being 11.75 grains out of 1000 of cloth. Another piece of similar cloth, weighing 5936 grains, yielded 63 of ashes, which is 10.6 out of 1000. The mean may be reckoned at about 1.1 per cent., a quantity three times greater than the mean of the two last incinerations of the white calico.

The pulverized ashes of the red cloth afforded to boiling water no appreciable portion of alkaline or soluble saline matter. The water, indeed, browned the yellow of turmeric, but this effect proceeded from some lime, rendered caustic during the ignition. The insoluble incinerated matter was treated, at a red heat, with thrice its weight of hydrate of potash. The fused mass was digested in boiling water, and the whole thrown on a filter. The liquid which passed through was slightly supersaturated with muriatic acid, and then with ammonia, when a copious precipitate of alumina took place. This alumina was subsequently tested by

caustic alkali. The weight of alumina, after edulcoration and ignition, was $16\frac{2}{3}$ parts on 100 of ashes.

The matter insoluble in the potash ley, which remained on the filter, was acted on by dilute muriatic acid, the excess of which was thereafter expelled by a gentle evaporation and ignition. Boiling water was then digested on the mass, and the solution being filtered was decomposed by oxalate of ammonia, which threw down an abundant precipitate of oxalate of lime, affording, after washing, drying, and cautious ignition, 39 grains of calcareous carbonate. The solution, freed from lime, was tested for magnesia by ammonia and phosphate of soda, but no trace of this earth appeared.

The pulverulent substance deprived of the above alumina and carbonate of lime was of a brown colour, and weighed 43 grains. I found it to consist of phosphate of lime, sulphate of lime, with minute portions of magnesia and alumina, besides peroxide of iron, amounting by itself to 8 grs.

From 100 parts of the ashes of the pink Turkey-dye only 2 parts of alumina were procured, being about one-eighth of the quantity obtained from the full-dyed red cloth. The other constituents of this incinerated matter were similar to those already specified. A trace of silica was perceived.

A watery decoction of madder-root was strained through cloth, and evaporated to dryness on a steam-bath. A portion of this extract being dried and ignited, left an incinerated matter, containing the very same constituents as the ashes of cotton-wool and cotton-cloth. A very faint trace of alumina was observable, but so slight as to be quite inadequate to account for the quantity of this earth obtained from the ashes of the pink calico. Hence I considered the point in dispute as sufficiently determined, since the pale-red or pink cloth, or portion of cloth, to which the aluminous mordant is not directly applied, evidently acquires it from the bath in which the mordanted pieces or portions of cloth are dyed up. But it is, I believe, especially in the final or brightening operation of the Turkey-red process, that a quantity of the dyeing materials, including mordants and madder, are drawn or

thrown out of the deeply-dyed calico, and transferred to the unmordanted fibres of the same, or of other pieces.

To investigate by experiment the nature and effects of the several operations of the Turkey-red dye, is a very interesting but laborious chemical problem. Having recently erected a laboratory, in which such researches may be conveniently carried on, I hope ere long to enter on them, assisted by the skill of the liberal-minded Turkey-red manufacturers of this city.

Glasgow, April, 1826.

Art. XIV. *An Account of the Analysis of some Roman Coins selected from the several Series denominated Large, Middle, and Small Brass. By the late* Samuel Parkes, Esq., F.L.S., &c. &c.

[Communicated by his son-in-law, J. Hodgetts, Esq.]

Some years ago I undertook a course of experiments on the alloys of tin, lead, and bismuth; and lately, in writing an essay on the manufacture of brass, a question arose whether any of the combinations of copper, tin, and zinc, now employed by the British workers in metals, are similar to those which were made use of in the fabrication of the national coins of ancient Greece and Rome. The subject appeared to deserve attention, and I immediately determined to select a few specimens of the brass Roman coinage, issued at times considerably distant from each other, and submit them to analysis.

The method to which I had recourse was that proposed by Mr. Keates, in the *Annals of Philosophy*, for the analysis of English brass; and this with such modifications as were required to adapt it to the examination of Roman coins, was in every instance adopted.

When the coins had been selected, they were first immersed in a mixture of three parts by weight of sulphuric acid, one part nitric acid, and two parts water; and in this they were allowed to remain a sufficient time to remove the *ærugo*, as medallists call it, that adhered to them. The weight of each coin was then

noted, and its specific gravity ascertained. A few shreds were then cut from the edges of the larger coins for the analysis; but when the coins were very small, they were generally used entire.

In the conducting the analysis, the fragments cut from each coin were weighed, and dissolved in pure nitric acid, of the specific gravity of 1.226. When the action ceased, the solution was poured on a filter, to separate any insoluble matter, which was carefully examined. A portion of the fluid which had passed the filter was then boiled for a moment in a test-tube, to ascertain if it contained any tin that had not already been peroxidized by the simple action of the nitric acid. Another portion of the solution, previously neutralized, was treated with sulphate of soda, to ascertain if it contained lead, and if this substance was indicated, more of the same sulphate was cautiously added to the whole of the solution, until it ceased to generate the metallic sulphate.

The iron, tin, and lead having thus been separated, the remaining solution was boiled, with the addition of a little sulphuric acid, for the purpose of dissipating the nitric acid that had been employed to dissolve the coin, and the whole was evaporated to dryness.

The dry mass was dissolved in weak sulphuric acid, added a little in excess; and when the solution was entirely effected, it was diluted with a large portion of water. The whole was then brought to a boiling heat, and a few pieces of pure iron were introduced for the purpose of precipitating the copper. The slips of iron were then taken out, and the remaining contents of the vessel poured, while hot, upon a filter, for the purpose of collecting the copper, which was immediately washed with diluted sulphuric acid, and afterwards with boiling water. It was then dried as quickly as possible, and its weight noted. If a doubt existed whether any part of the copper had become oxidized in drying, the whole was converted into a peroxide, and the quantity of the metallic copper indirectly inferred.

The copper having thus been obtained, the fluid from which it had been precipitated was boiled with a little nitric acid for the purpose of converting the iron dissolved during the precipitation

of the copper into a peroxide. The free acid in the solution was then nearly neutralized by the addition of carbonate of soda, after which pure ammonia was added in considerable excess, to throw down the whole of the oxide of iron.

If any metal now remained in solution it was generally the oxide of zinc, the quantity of which was ascertained by the following method. Muriatic acid was first added to saturate the ammonia, which had been employed in sufficient quantity to precipitate the oxide of iron, and redissolve the oxide of zinc; and when the solution had been reduced to dryness, the mass was exposed to a proper degree of heat to drive off the muriate of ammonia. What remained was then dissolved in very dilute muriatic acid, and from this the zinc was readily separated by means of a solution of carbonate of soda. The precipitate of carbonate of zinc was then heated to redness, to expel the carbonic acid, and the oxide of zinc weighed. From the weight of the oxide that of the metallic zinc was deduced.

From the frequent occurrence of arsenic in the ores of copper, it was suspected that this metal would appear during the analysis of these coins, but none could be discovered by any of the usual tests.

During these investigations several methods were adopted to verify or correct the amount of the respective products; and it was with this design that many of the experiments were repeated, care having been taken to reserve a portion of each coin, or of its solution, for this purpose. In like manner, when the iron, tin, and lead had been precipitated, the remaining solution was invariably examined to see if it contained more of either of those metals; and whenever the last result, *viz.*, the oxide of zinc, had been obtained and weighed, a part of it was redissolved in an acid, and tested for copper, lead, and tin.

In relating the final results, I have thought it expedient not to confine myself to the order in which the alloys were examined, but to arrange them according to the periods in which the several personages lived whose coins had been the subjects of the experiments.

A. D. 26. I. Agrippina, *wife of Germanicus, the Nephew of the Emperor Tiberius.*—This was a coin in large brass with the legend "Agrippini Imp. Mater Caius Cæsar." On the reverse was a funeral car, with the words, "Diva Agrippina" in the field, surrounded with the letters, denoting Senatus Populusque Romani. This coin which had the colour of British brass, had the specific gravity of 8.551, and weighed 303 grs. That part which was submitted to experiment, weighed 55 grs. Its analysis gave

Copper	49 grs.
Tin	1.78
Zinc	3.26
Loss	0.96
	55.

A. D. 42. II. Claudius. A coin in large brass with a laureated head of the emperor on the obverse, surrounded by the legend "Tiberius Claudius Cæsar Augustus, P. M. Trib. Pot." On the reverse, figure of *Hope*, with the legend "Spes Augusta." It has been supposed that this coin was struck on the invasion of Britain, as the figure personifying Hope holds out a flower, probably the lily, as the omen of victory. This coin weighed 369 grs.; it cut remarkably tough, and was of the specific gravity of 8.559. The quantity dissolved was 62 grs., and its analysis gave

Copper	54 grs.
Tin	2.37
Zinc	4.08
Iron	0.69
Loss	1.46
	62.

A. D. 70. III. Vespasian. A coin in large brass, with a fine laureated head of the Emperor on the obverse, surrounded by the legend "Imp. Vespasianus Augustus, P. M. Tr. P." The reverse, like the former, had a full-length figure of *Hope*, with the legend "Spes Augusta," and the usual S. C. inscribed on the field. This coin was of a bright yellow colour, much resembling gold—it weighed 370 grs., and its specific gravity amounted to 8.459.

The portion dissolved was 56 grs., and the result of the analysis was

Copper	42	grs.
Tin	1.58	
Zinc	11.41	
Loss	1.01	
	56.	

A. D. 79. IV. TITUS.—A coin in large brass, weighing 354 grs. The obverse had a fine likeness of the emperor, with the legend "Titus Vespasian, Aug. P. M. Tr. P." The reverse bore the figure of *Peace*, with an olive branch in one hand, and a cornucopiæ in the other, with the legend "Pax Augusti," and the S. C. inscribed on the exergue. This coin was composed of a softer alloy than usual, and when cut, had the colour of fine brass. Its specific gravity 8.875. Sixty-eight grains of the metal were dissolved, and consisted of

Copper	56	grs.
Tin	2.37	
Zinc	8.76	
Loss	0.87	
	68	

A. D. 81. V. DOMITIAN.—A coin in middle brass, bearing the head of Domitian ornamented with laurel, on the obverse, surrounded by the legend "Imp. Cæsar Domitianus Aug. Ger." The reverse had a full length figure of the emperor, graced with a trophy, and with a captive kneeling. The legend on this side of the coin was "Germania Capta." It had S. C., as usual, on the exergue. The whole weighed 284 grs., and had a specific gravity of 8.323. The portion taken for analysis weighed 82 grs., and was found to contain

Copper	70	grs.
Tin	1.58	
Zinc	9.78	
Loss	0.64	
	82	

A. D. 96. VI. Nerva.—A coin in large brass, with the head of the emperor laureated, and the legend "Imp. Nerva Cæs. Aug. P. M. Tr. P." Nerva having been raised to the purple by the unanimous vote of the Senate, this coin was struck to celebrate his promotion; the reverse of which exhibited the figure of *Fortune* holding the helm of a ship in her right hand, and a cornucopiæ in her left, with the legend "*Fortuna August.*," and S. C. in the exergue. The coin was the colour of modern brass; it had the specific gravity of 8.746, and weighed 399 grs. Of this piece 66.5 grs. were dissolved, and the solution afforded

Copper	50	grs.
Tin	3.15	
Zinc	10.79	
Iron	2.39	
Loss	17	
	66.5	

A. D. 98. VII. Trajan.—A coin in large brass, weighing 378 grs. The removal of the outer coat, by acid, reduced it to 373 grs. This coin bore the head of the emperor surrounded by the following legend, in an exceedingly small, but very distinct type, "Imp. Cæs. Nerva Trajanus Augustus Germ. P. M. Cos. II. P. P." The reverse had Trajan on horseback, in the act of leaping over a prostrate enemy, to avoid trampling upon him. The legend on this side was "S. P. Q. R. Optimo Principi," with S. C. in the exergue. I found this alloy, the sp. gr. of which was 8.648, to be composed of

Copper	322	grs.
Zinc	29.34	
Tin	12.60	
Lead	6.84	
Loss	2.22	
	373.	

A.D. 117. VIII. Sabina, *wife of the Emperor Hadrian.*—A coin in large brass, of the specific gravity of 8.715, weighing 364 grs., with a head of the empress, and the legend "Sabina

Augusta Hadriana." On the reverse was a full-length figure of Venus, with the legend "Veneri Genetrici." The dissolved portion of this coin, which cut very much like British brass, weighed 66½ grs., and by analysis gave

Copper	52.5 grs.
Zinc	12.24
Tin	1.58
Loss	0.18
	66.5

A. D. 161. IX. Faustina *the younger, wife of Marcus Aurelius Antoninus.*—This coin was of large brass. It had a specific gravity of 8.634, and weighed 331 grs. The obverse had a fine head of the empress, surrounded by the words "Faustina Augusta;" the reverse a full-length figure of Health, with the legend "Salus Augusta," and S. C. in the exergue. It had nearly the colour of copper, and its texture was rather brittle. The part taken for experiment weighed 59 grs., which produced

Copper	45 grs.
Zinc	9.78
Tin	3.15
Loss	1.07
	59

A. D. 180. X. Commodus.—A coin in large brass, weighing 381 grs., spec. gr. 8.728, extremely brittle, and nearly the colour of nickel, when cut. The obverse had a head of Commodus, with the legend "Commodus Felix Augustus." The reverse, a seated figure of *Hygeia*, with a serpent, emblematic of health: the legend, "Salus." Sixty-seven grains of this coin gave

Copper	52 grs.
Zinc	4.89
Tin	3.55
Lead	5.46
Iron and Loss	1.13
	67

A. D. 193. XI. Julia, *wife of the Emperor Severus.*—A thick coin in middle brass, weighing 320 grs., spec. grav. 8.648. The obverse had a fine head of the empress, with the legend "Julia Domna Pia Felix Augusta." The reverse exhibited a full length figure of *Venus:* the legend merely "Felicitas Publica," with the usual S. C. inscribed on the field. Seventy-four grains of this coin yielded

Copper	64.50 grs.
Zinc	4.08
Tin	3.15
Lead	1.02
Loss	1.25
	74

A. D. 222. XII. Alexander.—A coin also in middle brass, weight 251.5 grs., spec. gr. 8.765. The head of the emperor was encompassed with the legend "Imp. Alexander Pius Augustus." On the reverse was a figure of *Hope*, with her emblematic flower in the right hand, and the legend "Spes Publica." The S. C. was inscribed on the field. The solution produced

Copper	160 grs.
Zinc	48.90
Tin	7.90
Iron	2.79
Lead	27.32
Silver	1.13
Loss	3.46
	251.50

A. D. 224. XIII. Otacilia Severa, *wife of Philip the Elder.*—A coin in middle brass, weighing 295.5 grs. The external oxide being entirely removed, the piece weighed only 267 grs., and had the sp. gr. of 8.954. The obverse had a very fine head of the empress, surrounded by the legend "Marcia Otacilia Severa Augusta." On the reverse was a figure intended to personify *Piety*, with the legend "Pietas Augustæ." The whole of this coin was dissolved, and its constituents were

Copper	178 grs.
Zinc	49.72
Tin	12.60
Iron	2.44
Lead	20.89
Silver and loss	2.60
	267

A.D. 260. XIV. Posthumus, *one of the Usurpers who erected a standard in Gaul, in the reign of the Emperor Gallienus.*—This was a very brittle coin, in small brass, weighing only 40½ grs., spec. gr. 8.4. It bore the galeated head of Posthumus, with the legend, "M. C. Latienus Posthumus Augustus." The reverse had a Roman soldier, with the legend "Neptuno Reduci." This alloy consisted of

Copper	32.50 grs.
Zinc	4.08
Tin	3.15
A slight trace of iron, and loss .	0.77
	40.5

A. D. 260. XV. Victorinus, *another of the Usurpers, proclaimed in Gaul during the reign of Gallienus.*—This was a coin in third brass, made with a tough alloy, weighing 58 grs., and of the spec. grav. of 8.285. It had a head of the usurper, with the legend "M. Piauvonius Victorinus Augustus." The reverse displayed a Roman soldier in full armour, with the legend "Salus Aug." I procured from it

Copper	50.0 grs.
Zinc	3.88
Tin	3.55
Loss	.0.57
	58

A. D. 270. XVI. Aurelian.—A coin in small brass, weighing 62 grs., spec. gr. 8.333. It had a head of Aurelian, with this legend, "Imp. Aurelianus Augustus." On the reverse was a soldier, bringing tribute to the emperor, with the legend "Resti-

tutor Orientis." The words "Jovi Victori" were visible on the exergue. This produced

Copper	52	grs.
Zinc	5.30	
Tin	1.58	
Iron	1.04	
Lead	1.02	
Loss	1.06	
	62	

An attempt of the emperor Aurelian to reform the coinage occasioned a rebellion, which was excited by the workmen in the mint, of the most formidable nature. The circumstance will, however, be adverted to hereafter.

A. D. 276. XVII. Probus.—A coin in small brass, weighing 72 grs., spec. grav. 8.470. The legend round the head of the emperor was "Imp. C. M. Aurelius Probus P. F. (Pius Felix) Augustus." The reverse shewed two captives kneeling, and it had the legend "Restitutor Orbis." The single letter S. was inscribed on the field, and the figures XXI on the exergue. This coin afforded the following results:—

Copper	58	grs.
Zinc	8.16	
Tin	3.15	
Lead	1.37	
A trace of iron, and loss . . .	1.32	
	72	

A. D. 306. XVIII. Constantine.—A coin in middle brass, weighing 98 grs.; spec. grav. 8.711. It bore the head of Constantine, with the legend "Imp. Constantinus Augustus." The reverse had a full-length figure of a Roman soldier completely armed, and surrounded with the legend, "Soli Invicto Comiti." It had also T. F. inscribed on the field, and P. T. R. (Pecuni Treverensis) in the exergue. This coin lost one grain by cleaning the surface, so that when it was submitted to analysis, it weighed only 97 gas., and these gave—

Copper	80 grs.
Zinc	2.45
Tin	6.69
Lead	5.47
Silver, and loss	2.39
	97

A. D. 340. XIX. Constans.—This piece was a Roman assarium, weighing $34\frac{1}{4}$ grs., and of the spec. grav. of 8.928. The assarium was the smallest coin known to the ancients. Mention is made of it by St. Matthew. "Are not," says he, "two sparrows sold for an assarium?"—(Chap. x. ver. 29.) These coins, which are usually classed with the small brass, have generally a well-executed head of the emperor, with the legend "Fl. Jul. Constans Pius Felix Augustus." The reverse on this particular coin had two full-length figures, with the legend "Victoria D. D. Augg." and T. R. P. on the exergue.

Copper	30.25 grs.
Tin	0.78
Loss	0.22
	31.25

A. D. 364. XX. Valens.—A copper assarium of this prince, weighing $27\frac{1}{2}$ grs., and of the spec. grav. of 8.80. The legend on the obverse was "Dominus Noster Valens Maximus Augustus," completely surrounding a very neat head of the emperor. The reverse exhibited a fine full-length figure of a Roman soldier, intended probably to represent Valens himself. The legend here was "Gloria Romanorum." This coin yielded—

Copper	24 grs.
Tin	0.59
Lead	2.05
A trace of silver, and loss . . .	0.86
	27.5

A. D. 383. XXI. Arcadius.—This was a very minute assarium, with a beautiful head of Arcadius, surrounded by the

legend "Fl. Arcadius P. F. Augustus." The reverse had a whole-length figure of the emperor, with the words "Salus Reipublica." This coin, though in fine preservation, weighed only $13\frac{1}{2}$ grs. It had the colour of bronzed copper; its spec. grav. was 8.307, and it gave, on analysis,

Copper	12 grs.
Tin	0.79
Loss in analysis	0.71
	13.5

A. D. 403. XXII. Theodosius II.—Another diminutive assarium, weighing 18 grs., with a spec. grav. of 9.00. This elegant little coin had a neat head of the emperor, with the legend "Dominus Noster Theodosius P. F. Augustus." The reverse had no legend, but merely an inscription, on the centre of the field, of the words Not X. Mult XX. surrounded by a wreath. It gave, on analysis—

Copper	11.50 grs.
Zinc	4.08
Tin, with a very slight trace of iron	1.68
A trace of lead, and loss . . .	0.74
	18

Although the foregoing coins varied considerably in the proportions of their ingredients, it must have been remarked that, in every instance, *tin* was found to be a component part. This circumstance may at first appear extraordinary, especially as the coins were taken promiscuously from a series which embraced the four first centuries of the Christian era; but, on further consideration, it may, perhaps, admit of a satisfactory explanation.

It is well known that tin, though in itself very little harder than lead, possesses the property of imparting great hardness to copper, and even when the former metal bears but a small proportion in the alloy; and as there are many facts on record to prove that the ancients were acquainted with this property of tin, there

can be no doubt as to their motive for employing that metal in their brass coinage.

It will be recollected that tin was known in the earliest ages of which we have any account; that it was in use even in the time of Moses *; that it is mentioned by Homer as one of the metals employed in the construction of the shield of Achilles †; and that we have the testimony of a writer six hundred years before Christ, that tin was sought after by the Phœnicians, who carried it to Tyre, one of the chief cities of Phœnicia, as an article of merchandise ‡. Another of the sacred writers also informs us that Moses made a laver of brass with the looking-glasses of the women §; and as neither brass nor copper is of itself hard enough for the construction of mirrors, it is reasonable to suppose that these looking-glasses, which were brought to the prophet as a religious offering, were formed with a metallic compound of which tin made a part. That such an alloy possesses the quality of reflecting objects in a high degree, is well known from the circumstance of its being invariably employed in composing speculum-metal, to which purpose copper alone is quite inapplicable.

I am aware of the general notoriety of these facts, but I hope to be excused in having adduced them here, and also in briefly observing, by way of further elucidation of the subject, that tin in conjunction with copper was likewise employed by the ancients for constructing their various weapons of war; and that none of these remains of antiquity have hitherto been discovered made of pure copper.

From these testimonies we may justly infer, that all the warlike instruments of antiquity were formed with an alloy of these two metals. The tin not only hardened these weapons, but it gave them that tenacity which enabled the workmen to grind them to a fine edge, so as to make them efficient cutting implements, which were always harder and of a closer texture, in proportion to the weight of tin contained in them. The tin also ren-

* *Numbers,* xxi. 21, 22. † *Iliad,* lib. xviii. line 474; Elzevir, 1656.
‡ *Ezekiel,* xxvii. 12. § *Exodus,* xxxviii. 8.

dered these more durable, as their edges must have been less liable to be oxidized or injured by the action of a damp atmosphere. There appears, however, to be a limit to the proportion of tin, for Muschenbroeck proved, by direct experiment, that when one part of tin was added to five of copper, the alloy became so hard that a file would scarcely touch it, and that in this state it was only fit for the fabrication of mirrors.

It is probable that the manufacture of military instruments was anterior to the coining of money; therefore, when the Greek and Roman coins became the general circulating medium, the employment of a similar alloy for the latter purpose seems to have been a natural consequence.

The addition of zinc, whereby the copper becomes converted to brass, was equally judicious; inasmuch as the mixed metal is harder and less disposed to tarnish by exposure to the atmosphere. The compound nature of this peculiar alloy gave it also that malleability and tenacity which enabled it to receive the finest impressions of the die without cracking—besides which, its superiority of colour, and its capability of taking a high polish, are qualities which rendered it very appropriate for the fabrication of an elegant coinage. Accordingly we find, that the coins known under the denomination of "large brass," are really made with brass and an admixture of tin, and not of copper, especially those in the earlier ages of the Roman empire. In this all medallists agree—consequently, the coin current in Great Britain, after the descent of Claudius, must have been brass alloyed with a small portion of tin. The estimation in which brass was held by the ancients, appears also from Pliny, who says that brass was double the value of copper. From other sources we likewise learn, that the coinages of brass and copper were in these times kept as distinct as those of gold and silver are at the present day.

These considerations are quite sufficient to account for the admixture of tin and zinc in the Roman money; but I confess I was much surprised to find among the coins which I examined only three, and those in small brass, which did not contain the latter metal.

The coins washed with silver, which began to be issued about the time of Valerian or Claudius Gothicus, are all, as far as I have seen, fabricated of copper, as being the cheaper metal; a proof, this, that the colour of brass was in greater estimation than that of copper.

Why the Romans should have used lead in their brass money does not perhaps admit of a very satisfactory explanation, unless we suppose it to have been added for the sake of imparting that degree of toughness to the copper alloy which it does not of itself possess, but which is so desirable for the purpose of coining. Muschenbroeck says that lead adds much to the firmness and hardness of tin. He found that an alloy made with four parts of tin and one of lead was twice as hard as pure tin. Lead has also the effect of rendering an alloy of copper and tin more fusible. It is well known to many of our artists, that lead and copper, without any other admixture, forms a very hard and tough alloy; and with this intention such a mixture is actually employed in the fabrication of the largest kind of printers'-types, and Savary has written to shew what proportions are best for the purpose. Could it be proved that the Romans knew of this property of lead, it would shew that they had a more extensive knowledge of Metallurgy than has generally been supposed.

The iron which occurs in the brass coins of Rome may be considered rather as a contingency arising from the impurity of the zinc, of which the brass was composed, and not as a designed addition. Even in our time, we know that it is very rare to procure either zinc or its ore entirely free from iron. It is not likely, however, that the ancients were aware of the impurity of the ores of zinc, or that a small portion of iron would contaminate an alloy of copper; nor can we suppose they were in possession of any means of separating this impurity.

The silver which was separated during the analysis of four of the coins, must have found its way into them by accident, as it cannot be supposed that this precious metal was added by order of the senate; and from the S. C. which appeared on the two largest of these pieces, it is evident that they were coined in con-

sequence of a decree of that body. No silver occurred in either of the other coins, though each of their solutions was carefully tested for the purpose of detecting that metal.

If the metallic alloys which were made use of in the Roman mints were properly adapted to the purpose of forming a general currency for that great people—and really the superiority of such alloys does appear to have been confirmed by experiment and experience—it seems strange that every modern European power should have adopted pure copper, instead of attempting to imitate, in some way or other, what had so long and so successfully been employed by the nations of antiquity.

It is true there are instances in modern times of brass having been used in Great Britain for the fabrication of coins and medals, but these are very rare. In the seventeenth century a very fine medal of brass was found in Knaresborough forest, bearing the date of 1480, and this, as I understand, is now in the cabinet of the Duke of Devonshire. In 1672, Charles II. issued pattern-farthings of brass; and in 1678, brass medals were cast from the silver ones which had been issued on the occasion of the murder of Sir Edmundbury Godfrey. In 1689 and 1690, King James II. coined sixpences, shillings, and half-crowns in Ireland from some brass cannon, which he found there on his landing from France after his abdication of the crown of England. I have also seen a Queen Anne's farthing in brass, though these were generally of copper; and in 1723, George I. coined some money for his American subjects, of various sizes, bearing the rose and crown on the reverse, with the legend *Rosa Americana*, which were made of Bath-metal, or an alloy of brass and copper. These, I believe, are the only instances of coins being manufactured in this country of brass. James II. indeed issued a coinage of unalloyed tin, to the amount of sixty thousand pounds; but, in 1693, this money was called in by King William, and the copper-coin recommenced.

This substitution of copper is the more to be lamented, because pure copper is much less beautiful and tenacious than any of its alloys with tin and zinc, as adopted by the Greeks and Romans.

Moreover, there can be no objection to the employment of tin on account of price, as this metal, though generally dearer than zinc, is often much cheaper than copper.

The insurrection of the workmen of the Roman mint, to which I alluded when reporting on a coin of the Emperor Aurelian, demands an observation or two before I conclude.

The relation of this singular occurrence is given by Vopiscus *, Zosimus, and other of the Augustan historians †, but neither of them has attempted to explain or account for the extraordinary circumstances attending it. Gibbon contents himself with little more than a bare recital of the transaction. "The attempt of Aurelian," says he, "to restore the integrity of the coin was opposed by a formidable insurrection. The emperor's vexation thus breaks out in one of his private letters. 'Surely,' says he, 'the gods have decreed that my life should be a perpetual warfare. A sedition within the walls has just now given birth to a very serious civil war. The workmen of the mint, at the instigation of Felicissimus, a slave to whom I had intrusted an employment in the finances, have risen in rebellion. They are at length suppressed, but seven thousand of my soldiers have been slain in the contest.'" Other writers who have confirmed the fact, say that the workmen of the mint had adulterated the coin, and that the emperor restored the public credit by delivering out good money in exchange for the bad which the people had been commanded to bring into the treasury ‡.

Pinkerton says, that "the managers of the mint, apprehending a diminution in their profits from the alteration of the coin, drew up their workmen in a body against the army of the emperor, and that upon being defeated they left forty thousand of their men dead upon the field §." This writer, however, has not quoted his authority for this additional circumstance in the story.

* *Scriptores Historiæ Augustæ*, in 2 vols. 8vo. Lug. Batav. 1671. Vopiscus, Tome ii. page 517, &c. *Historiæ Augustæ Scriptores Minores*, folio, 1611, page 425.

† *Aurelius Victor*, Arntzen, 4to. 1733, page 408 et 557.

‡ *Zosimi Historiæ Reitemeier*, Lipsiæ, 1784, lib. i. cap. lxi.

§ *Essay on Medals*, duodecimo, London, 1784, p. 44.

Notwithstanding the numerous provinces that were subject to the Roman power, and the large quantities of coin that were necessary for the service of so extensive an empire, it is difficult to conceive how so many individuals could be employed in the offices of the mint—even if it were true, as some medallic writers have asserted, that the Romans never issued two coins of the same metal perfectly alike, but that an alteration was made in the die for every coin that was struck. M. Beauvais, the eminent medallist, asserts that he had never seen more than two Roman coins of the imperial ages perfectly similar, and those were of Galba.

During my own acquaintance with Roman coins, I do not remember ever to have seen two that were exactly like,—and yet the numbers which occur of some emperors with different reverses is truly astonishing. M. Genebrier had twelve hundred coins of Constantine the Great, all in small brass; and the Abbé Rothelin had no less than eighteen hundred coins of the Emperor Probus *, whose reign scarcely exceeded six years. In my own collection there are more than three hundred coins of the former of these emperors, and fifty or sixty of the latter, although my cabinet would be deemed one of very minor importance. Among the whole, however, I have not been able to find any two that correspond in every respect,—as those which are the nearest alike, still differ from each other, either in size, in the figures impressed on the reverse, in the inscription, or in one or both of the legends.

I once endeavoured to call the attention of the public to this curious historical fact, by some letters which I published about thirty-five years ago, in a periodical work of that time and though the subject was taken up by a gentleman well versed in Roman antiquities, his conjectures were not altogether satisfactory.

M. D'Hancarville has endeavoured to account for the large number of ancient coins in fine preservation, by observing that it was always the custom of the ancients to bury one or more

* *Essay on Medals,* third edition, 8vo. 1808, vol. i. page 70.

coins with their dead *. The same author calculates that, from Phidon of Argos to Constantine there were thirty-six generations, and that in those countries where the fine arts prevailed the inhabitants amounted to thirty millions; consequently there must have died during that period, and in that region, not less than one thousand millions of people, each individual having a coin or coins of one species or other deposited with him in his grave †. Mr. Pinkerton endeavoured to remove all difficulties, by saying, that it would be surprising if any two ancient coins were now found struck with the same die, because, out of each million issued, not above one coin has reached us. A most extravagant assertion truly. Dies, he says, soon give way by the violence of the work, and the ancients had neither puncheons nor matrices, but were obliged to engrave many dies for the same coin ‡.

The abundance of the colonial coins may in some measure be accounted for by the circumstance of the Romans having established their argentaria in such a variety of places. It is well known that there was usually a mint in the capital of every province, which must have rendered the monetarii extremely numerous; and that the privilege of coining money was likewise allowed to the commanders of their armies, and executed by the Quæstors for the payment of the troops. These combined facts do not, however, sufficiently account for the endless variety which is observable in Roman coins.

* D'Hancarville, *Recherches sur l'Origine et les Progrès des Arts de la Grèce, &c.* 3 *tom.* 4*to*, London, 1785, tom ii. page i., &c.

† *Ibid.* tom. ii. page 43.

‡ *Pinkerton on Medals,* third edition, 1808, vol. i. page 67.

Art. V. *Observations upon a Paper published in the second part of the Philosophical Transactions for* 1826, *entitled,* "*Description of an improved Hygrometer. By* Mr. Thomas Jones. *Communicated by* Capt. Henry Kater, F.R.S." *By* J. F. Daniell, F.R.S.

In the course of a tour which I made in Germany in the early part of the year 1825, an instrument was shewn to me by some of the ingenious artists of that country, which was intended for a simplification of my hygrometer. It consisted of a large-bulbed thermometer, the stem of which was bent twice at a right angle. On the top of the bulb a small cup was formed, in which a piece of cotton was placed and moistened with ether; by the evaporation of which the mercury was cooled till dew appeared upon the surface of the glass. It was supposed that the temperature of the dew-point would be indicated at the moment this precipitation took place by the scale of the thermometer. Experience soon proved that this indication could not be depended upon, and the instrument was consequently rejected. I purchased one of these hygrometers at Berlin, and another was presented to me by the Grand Duke of Weimar, and both are now in my possession.

Under these circumstances it was with a considerable degree of astonishment that I read in the second part of the *Philosophical Transactions* for the year 1826, recently published, a description of this same instrument, under the title of an *Improved Hygrometer, by Mr. Thomas Jones. Communicated by Captain Henry Kater, F.R.S.* The President and Council of the Royal Society therefore "*consider it as proved*" that this adaptation of the thermometer is new; and further, that it constitutes an improvement of the hygrometer: both of which errors I feel myself called upon to correct, on account of the weight which they derive from such high authority.

The sole difference between Mr. Jones's instrument and those which I brought from Germany, consists in a piece of muslin being wrapped round the lower part of the bulb of the former, in-

stead of the piece of cotton placed upon the top of the latter; a variation which, although sufficiently insignificant, is, upon the whole, as I shall presently shew, detrimental to the intended observation. Mr. Jones, indeed, himself hardly asserts that his invention is new, for he modestly enough says, at the conclusion of his paper, "I ought also, perhaps, to mention that an instrument, somewhat similar in principle, has been used in Vienna, and was mentioned by Professor Baumgarten, of that capital, to a friend, who communicated the fact to myself." I have also reason to believe that when he originally made the instrument for a customer who wanted a *cheap* hygrometer, he little contemplated the honour which awaited him.

To those who are unacquainted with the politics of the Royal Society, it will, doubtless, appear extraordinary that the Council, who, in general, are so fastidious upon the score of novelty, as often to reject valuable communications, (as in the case of Mr. Barlow's first papers,) because some of the facts have been previously published, should all at once lose sight of this fundamental rule of their decisions. However, I am one of those who think that the promotion of natural knowledge might sometimes be effected by a less strict enforcement of this law in cases where new matter is almost necessarily mixed up with what is already known, and that the importance of a subject might sometimes even justify its suspension. But this second edition before me is that of an invention which is utterly incapable of answering its intended purpose.

This, I should have supposed, would have been so extremely obvious to any person in the least acquainted with the time which necessarily must elapse before a thermometer, containing a large quantity of mercury, will mark the temperature of a fluid in which it is even wholly immersed, that I could only have been induced to have expended any words in pointing it out by the magnitude of the authority by which it is supported.

In the first place, the thermometer being graduated by the total immersion of its bulb into a fluid of known temperature, how can it, for a moment, be supposed to indicate the temperature of an

evaporating fluid, into which it is afterwards only half immersed? Or, one half of the inch-long bulb being cooled by evaporating ether, and the other half being exposed to the temperature of the surrounding air, by what process of induction can it be established that the temperature denoted by its scale is that of one-half of its surface only?

In the second place, mercury, being a fluid, is an extremely bad conductor of heat, and when heat is applied to any mass of it unequally, an equal distribution is only brought about by a circulation of its different parts. This circulation will be more or less rapid, according as the differently-heated portions are more or less favourably arranged for the operation. Thus, in the original German contrivance, the cooling power being placed above, the circulation will be more quick than in that of Mr. Jones, where the refrigerating ether is applied below. In the former case, the heavy cold particles will rapidly fall and give place to the lighter warm particles; while, in the latter, the cold particles being below, will but slowly be driven from their station by the lighter warm particles above. Mr. Jones, moreover, contracts the diameter of his bulb below, and thus creates another obstacle to the interchange of particles, upon which so much depends.

In the third place, an equal distribution of temperature must take place in very unequal times, according as the partial cooling influence is more or less rapid in its effects; and as the evaporation of the ether will vary with every breath of wind, the result must always be uncertain. That these very simple propositions were not wholly unknown to Mr. Jones, appears from the following observation extracted from his paper:—"Should it be objected against the principle of the instrument here proposed, that the indications do not exhibit the true temperature of the upper surface of the bulb on which the deposition of dew takes place, but that of the lower part to which the ether is applied; it may be answered, that by inclining the whole instrument, so as to render the axis of the bulb horizontal, and establish thereby a free circulation of the mercury in every part, this objection may be obviated." To this it may be replied, that the indications do not exhibit the

true temperature of either the upper surface on which the deposition of dew takes place, or of that of the lower part to which the ether is applied, but a perpetually varying combination of both; and with regard to inclining the axis of the instrument, it does not at all appear how this can establish a free circulation in every part; and, indeed, Mr. Jones goes on to observe with perfect sincerity, "but on repeated trials I have not found this to produce any difference in the results."

I shall not now stop to inquire whether a stream of the vapour of ether rising so immediately under the condensing surface of the glass, and issuing with some force into the very portion of the atmosphere whose dew-point it is proposed to ascertain, may not interfere with the result, although I think that it would not be difficult to shew that such interference must follow; but I shall conclude with the particulars of an experiment which will, probably, work conviction upon those who have overlooked, or shut their eyes to, the preceding arguments.

I caused a glass bulb to be made of the exact form and dimensions of that of Mr. Jones's hygrometer, and having inserted one of the very delicate thermometers used by Mr. Newman in the construction of my hygrometers into the upper part, and another into the lower, I filled it with mercury: I then covered one-half with muslin, by wetting which with ether I readily produced a difference of 16° or 17° between the two small thermometers! This difference was never constant, but varied with every inclination of the bulb, and every variation of the cooling process. After this it is scarcely necessary to say that I have inquired of those who with much perseverance have endeavoured to make observations with Mr. Jones's hygrometer, and that they report that its indications are inconsistent, and not to be depended upon; and I am much misinformed if the Council of the Royal Society might not learn thus much from some of their own officers.

Art. XVI. *Proceedings of the Royal Institution of Great Britain.*

Friday, April 7th.—Mr. Faraday advanced various experiments and arguments from the lecture-table, in opposition to a generally-received opinion, that all solid and fluid bodies in vacuo, or surrounded by gaseous or vaporous media, give off or are surrounded by a vapour of their own, whatever be their temperature. His object was to show that a limit existed to this production of vapour, and that by diminishing temperature and those causes which favour the production of vapour, not merely was the tension of the vapour diminished, but ultimately such a state attained, that the previously-formed vapour would be condensed, or, if removed, no further portions would be produced. He first stated Dr. Wollaston's proof of the finite extent of our atmosphere; and considering its state at the extreme limit, concluded that any change of circumstances; by which the elastic force should there be diminished (and, amongst others, increase of gravity and diminution of temperature were pointed out), would cause perfect condensation of that portion of the atmosphere. He then referred to another force, which he considered equally efficient in overcoming the elasticity of an atmosphere reduced to a certain degree of tension, and causing its entire condensation: this was the attraction of cohesion, and many facts and experiments were referred to in illustration of it. These reasonings were then applied to various bodies with which we are acquainted, and the conclusion drawn, that some of these, as silica, alumina, iron, &c., sometimes supposed to exist in the state of vapour in the atmosphere, cannot take up that state under ordinary circumstances; and that other bodies, as zinc, mercury, &c., probably had their limits of vaporization within the range of diminished temperature which we can command.

Mr. Cuthbert exhibited in the library his beautiful Amician Microscope, in which concave mirrors of 0.6 and 0.3 of an inch focus being used, astonishing magnifying power was obtained with extreme distinctness and absence of all colour. See page 34 of this Volume.

Mr. PARKER laid various fine castings of the new alloy, called Mosaic Gold, upon the table.

The beautiful specimen of Penmanship executed as a tribute to the memory of the late Princess Charlotte, by Mr. WALTER PATON of Devonshire-street, was laid upon the library-table, and also an engraving made from it. It contained a great variety of styles of writing, and a minature portrait of the Princess inimitably executed by the pen in imitation of line engraving.

Friday, April 14*th.*—This evening Dr. GRANVILLE exhibited his numerous fine specimens of Mummies, and particularly that presented to him by Sir Archibald Edmonston, before the Members in the Lecture-room. Dr. Granville entered into a particular description of the latter, and detailed the course of investigations by which he was enabled to arrive at the novel and important conclusions contained in his Essay read to the Royal Society. The specimens and preparations were chosen and prepared for the particular illustration of these points. Dr. Granville has presented copies of his Essay to the Library.

Friday, April 21*st.*—Dr. HARWOOD read the first part of an Essay on the Natural History of the Elephant genus. This communication related chiefly to the Asiatic or present domesticated species, including an account of the individual lately destroyed at Exeter Change. It commenced with the mention of some curious particulars found among the writings of ancient naturalists concerning these animals. The peculiarities in the growth and construction of their grinding-teeth and tusks were next considered, and the means whereby musket-balls and other extraneous bodies become deposited within the latter, and are ultimately surrounded by the solid substance of the ivory. This part of the subject was illustrated by a number of specimens, including an *Asiatic* tusk, which measured nearly nine feet in length, and weighed upwards of 170 lbs. The longevity and production of elephants were then mentioned, the many ancient

and modern modes employed in their destruction or capture, and the several Indian varieties of these animals, were enumerated in succession. These subjects were succeeded by observations concerning the Exeter Change specimen, and the paper was concluded by remarks on the power and capabilities of elephants, the very numerous means in which they have been formerly, or are at present, employed in useful services, and the extraordinary extent to which in them the principal of subordination is carried.

In addition to many beautiful paintings which were exhibited illustrative of the above subjects, Mr. Cross of Exeter Change, with extreme liberality, granted, in furtherance of the object, the use of the broken portion of the tusk of his late elephant, and contributed other interesting specimens, including the skull of a large African elephant: and M. De Ville also, in the same spirit and for the same purpose, overcame the difficulty of conveying his massive cast of the head of the late Exeter Change animal to the Institution.—*(To be resumed.)*

A fine specimen of modern Illuminated Writing, being a facsimile of a page of an ancient Flemish Missal, was laid upon the table.

Friday, April 28th.—Mr. S. Solly came forward at the Lecture-room table with a series of Geological Specimens and Drawings, and made observations to the following purport:—The primary rocks are, by some geologists, considered as the bones of the earth's outer frame-work, and the softer secondary strata have been denominated its flesh, but recent observations have placed in doubt all distinctions between primary and secondary strata.

To satisfy an audience collected from different quarters of the globe, Werner was obliged to generalize his observations, but having never travelled, he was able only to describe his own country. His descriptions have furnished us with a basis of comparison and a clue to investigation, whose value is not lessened by the many corrections which are gradually wearing out his theory. His most active opponents are obliged to use his nomenclature.

In distinguishing older and newer strata he has, as is testified by those notorious stumbling blocks greywacke and old red sandstone, made use of a most fallacious characteristic colour, which depends on causes that constitute an interesting field of inquiry.

Mr. Solly states his conjecture on this subject in the hope of rendering geology a more entertaining and useful study. Viewing it as a science in which we must be guided by analogy, we ought to seek for similitude in those operations which nature allows us to witness. Much has been attributed to fusion and solution, which may be explained by mechanical action.

Some of our sandstone seems to be of Æolian formation.

If gravitation had been the only principle, the stratification of the earth would have been too regular. A conflict of elements was necessary to produce that diversity which furnishes the multiplicity of materials for human industry and ingenuity.

The general agency of subterranean heat is naturally suggested by the convulsions of the Neapolitan territories. To this impression we owe the recent dissertation by Mr. Scroope. In his map, the western side of the Fiord of Christiania is marked as volcanic, perhaps because Von Buch compared a part of it to Auvergne; but Professor Esmark, who has sent the specimens now before you, continues to view the whole as Neptunian, having a covering of granite, usually considered the fundamental rock.

In his last volume, Dr. Clarke says, Esmark's collection is filled with specimens illustrating the origin of substances improperly termed volcanic; among which he enumerates obsidian, pumice, porphyry, and basalt. Mr. Scroope helps to reconcile conflicting opinions, by attributing the fluidity of lava to water.

Mr. Solly has long had an idea of this marriage of fire and water, and believes the marriage-feast to have consisted in stewing the rocks containing zeolites or jelly-stones, compounded of a well-salted rock gravy. Some amygdaloid or toadstones appear to have been boiled; but the generality of trap-rocks Mr. Scroope supposes to have been merely baked or roasted by a slow fire.

On the source of the heat, Mr. Solly differs more widely with

the Secretary of the Geological Society than in the mode of its operation.

Having set out with Whitehurst, and kept a sharp look out for heavings of strata, compared notes with the vulcanists of Germany, felt the earth shake at Messina, observed the basalt of Antrim at the foot of Etna, and seen that of Saxony, with Derbyshire toadstone, peep out at Cape Passaro, like a mouse creeping out of a mountain without disturbing it, Mr. Solly sought in vain for peaked boiling-pots in Shropshire, Ireland, and Scotland, but was favoured with an illustration of Hutton by Professor Playfair at Salisbury Crags.

Von Buch, after noticing that basalt and porphyry were the dwelling-places of volcanoes, continues to class them with Werner; and the latter observing the general contiguity of basalt to combustible strata, supposed volcanoes to have originated in the combustion of beds of coal.

The name of pyroxine implies that the lava which contains it is fused basalt. The horizontal stratification of basalt, and its gradation downwards through the softer substance, wacke, into clay, convinced Werner it was not a volcanic product.

There are similar gradations in the Swedish rocks, from whose form the generic term trap has its derivation; they resemble the brick-kilns near this metropolis, and appear to have been baked in a similar way. In their dark colour and columnar divisions, these rocks resemble the basaltes of Germany, as well as those of Sicily and Antrim; but they contain neither the zeolites of the latter, nor the pyroxine of the former, of which there are corresponding specimens in our collection from Christiania, as well as other crystallizations, which Mr. S. attributes to a longer duration of the process, as well as to a difference of the materials. With regard to the phenomenon of the porphyry, which overlies the shell-limestone, being observed by Von Buch to underlie the zircon syenite, and granite, Mr. S. produced a specimen of the junction of the porphyry and syenite, which appears to be an alteration effected by heat in the crystallization of the latter. Mr. Solly read a description from Mackenzie's travels, of strata altered by internal combustion, and retaining part of the fuel, as is

frequently the case with basalt. The remainder of the paper, containing a more particular account of the different substances, and their relative position, was deferred.

In the library, Mr. Jopling produced several of his instruments intended to illustrate and apply the Septenary *System of Generating Lines by simple continuous Motion.*

The system is an arrangement shewing the *seven* simple methods of connecting two planes together, so that while one is at rest, the motion of the other may be regulated by means of a *point or centre*, *a right line*, or a *circular line*, and a tracer being at the same time fixed in any position on either plane, will draw a fair line upon the other plane. Each distinct method is called a division; and the seven simple methods of connecting the planes were shown by arranged diagrams, and explained by the apparatus. Specimens of lines, produced by each, were exhibited, which showed, in some degree, the powers of the principles. No limit exists to the combinations of the principles; but it was stated that no regulated motion could be effected without making use of one or more of these *seven.* The divisions were subdivided into classes and cases, according to the kind, quantity, and position of the motions; and to all these varieties terms have been given. Diagrams, to illustrate the various modifications in each case, were also shown.

Although it be necessary, in order to have a right comprehension of the system, to explain it by means of two planes, yet these, in different applications of the principles, are not required, as in the double cranks for the first division, and the straight slips of wood used for drawing lines in the fifth division; neither is it necessary, in order to draw a curve on a large scale, to have any finely-constructed instrument.

The known curves, that may be described on the principles of regulating the motion of a surface, and which are included in the system, are the Cardioides, the Circle, the Cissoid, the Conchoid, the Cycloid, the Ellipsis, and the Epicycloids. Besides these, there may, perhaps, be others which have not been discovered; particularly Hyperbolas, and the Parabola. The same means,

differently arranged, form the third and fifth divisions; the one producing finite, the other portions of infinite, lines.

It is considered that a knowledge of the various forms of the curves in the system, will facilitate in youth a refined taste, both in constructing and contemplating the outline and detail of every object of sight; and any curve once obtained, may be registered and repeated, either to the same, or of any other, size; so that, for example, any portion of a varying line, selected by an architect, for the form of an arch, may, with a temporary instrument, be drawn by the workman to the full size required, as correctly as a circle or an ellipse. In the construction of solids, the forms of two extreme parts being selected, suppose the forms of a midship frame and bow of a ship, all the intermediate frames may be drawn with the instrument; and these, when placed by any true law, with respect to position, will produce a fair body. And a familiar knowledge of the various cases of motion, with the modes of representing them, and their effects, it is considered must be of great service to the engineer.

Several specimens of type-music printing, by Mr. Clowes, were also laid upon the table. They were beautifully executed, and presented a perfectly clear and correct page. They were accompanied by a portion of music, composed in type, which, by being broken up, showed the complexity, and, at the same time, perfection of the system. A stereotype plate, cast from the types, was also exhibited.

Friday, May 5th.—Mr. Faraday gave a joint view of the researches of Mr. Hennel and himself, in illustration of the singular power possessed by hydro-carbon of entering into union with sulphuric acid, and neutralizing it. The subjects of Mr. Hennel's investigations were oil of wine, and the sulphovinates. Oil of wine is a perfectly neutral substance, produced at a certain period during the action of alcohol and sulphuric acid. When heated, it evolves combustible matter, and becomes highly acid: the combustible matter is hydro-carbon. Upon examining the acid thus produced, it is found to be the same with the *sulphovinic* acid; and,

united with bases, it formed *sulphovinates*, salts which were first produced by Dabit, about the year 1800; and which, though examined by various chemists since his time, never had their nature explained until Mr. Hennel made his investigations. The *sulphovinates* are more readily prepared by mixing equal weights of sulphuric acid and alcohol; allowing the mixture to remain for half an hour, adding carbonate of lead equal to the weight of the sulphuric acid first used, and then filtering, by which little else than *sulphovinic* acid is left in solution; and this, combined with bases, furnishes the salts, which, by crystallization, are rendered pure.

Oil of wine consists of 2 proportionals of sulphuric acid, 8 of carbon, and 8 of hydrogen. It is neutral; but by heat gives off half the carbon and hydrogen, and sulphovinic acid remains, composed of 2 proportionals of sulphuric acid, 4 of carbon, and 4 of hydrogen; and these elements, with the addition of 1 proportional of any base, form sulphovinates.

Sulpho-naphthalic acid, discovered and examined by Mr. Faraday, is formed by melting together 2 parts of naphthaline and 1 of sulphuric acid; dissolving the cold solid mass in water, and filtering: a mixture of the new acid, with sulphuric acid, is held in solution. Neutralizing this by carbonate of baryta, a soluble sulpho-naphthalate of baryta is produced, easily separable from the sulphate of baryta. This salt, decomposed by sulphuric acid, yields the pure *sulpho-naphthalic acid;* and this, with bases, forms sulpho-naphthalates. So much hydro-carbon is contained in this acid, as to amount to nearly three-fifths of its weight; and it neutralizes or destroys the saturating power of one half of the sulphuric acid present. The *sulpho-naphthalic* acid consists of 2 proportionals of sulphuric acid, 20 of carbon, and 8 of hydrogen; and the sulpho-naphthalates contain, in addition, one proportional of base.

Some observations were also made upon the production of salts having very peculiar and novel appearances, the results being produced by the presence of a substance obtained during the action of sulphuric acid and hydro-carbon. These experiments are still in progress in the laboratory of the Institution;

and as they may, at some future time, be brought forward more distinctly, were not dwelt upon, or any positive conclusion drawn.

Mr. Perkin's book of Patterns for Calico Printing, produced by Eccentric Lathe Turning, was laid upon the library table, and contained many hundred patterns resulting from the varied associations of similar lines.

There was also upon the table one of Mr. Perkins's engraved steel plates; and a steel roller with the engraving upon it, taken by pressure from the plate, and consequently in relief; and now fitted, by having been hardened, to convey the engraving to other steel or copper plates, by pressure alone.

A volume of Mr. Upcott's Autographs was also laid upon the table.

Friday, May 12th.—The subject of this evening was the improvements made by Lieutenant Drummond in geodesical and other similar operations, by the introduction of an object to be seen at one station from another, with a facility and at distances much greater than had heretofore been attained. In his various attempts to procure an object which should be most readily visible under unfavourable circumstances, he was, after trial of various pyrotechnical preparations, the combustion of phosphorus in oxygen, *&c.*, led to adopt a ball of lime intensely ignited, and placed in the focus of a parabolic mirror. This was the apparatus which was brought before the members. In the early part of the evening, the object, principles, and arrangement of the application was explained by Mr. Faraday, in the lecture-room; a mirror, mounted on its stand, and with its various adjustments, being on the table, but having an Argand lamp in its focus, arranged in the usual way. After this statement the members adjourned to the reading-room, where another stand and reflector was arranged, a ball of lime being adjusted in the focus. The lamp and its reflector was then placed by its side, and the ball of lime being heated by a set of five spirit lamps, urged by oxygen gas, the reflectors were moved round on vertical axes, so as to throw the light from the lamp and from the ball at the same

time over the audience, collected together at the other end of the room, at from thirty to forty feet distance. It has been found, by accurate experiment, that the intensity of the light from the ball is at a mean about 75 times that of the Argand lamp, but by careful management has risen up to 90; and the effect, when in the focus of the reflector, is quite blinding to those upon whom the light is thrown. The light has been put up at stations in the survey of Ireland, and in the first instance at Slievesnaght, in the north of Ireland, to be observed from Divvas-hill, near Belfast, a distance of sixty-six miles: it was immediately seen, although a delay of sixty-six days had previously taken place whilst looking for the usual object.

The application of the light to light-houses, especially such as are situated at the extremities of the land, or at sea, was also pointed out, and its probable expense and advantages stated.

Friday, May 19th.—Mr. Turrell resumed the subject of Engraving, principally with reference to the execution of works of art upon Steel, for the purpose of procuring a very large number of impressions. The metallurgical operations, through which good pig iron passed before it became tough iron, and ultimately steel, were briefly described and illustrated; and the principle, which Mr. Perkins has so advantageously adopted, of the transference of designs by pressure from hard to soft steel, explained. The consideration of engraving directly upon steel, and the nature of the menstrua required for the etchings, were not particularly entered into, for want of time. Mr. Turrell had present a very fine impression from a mezzotinta engraving of Martin's picture of Belshazzar's feast. It was twenty-eight inches by nineteen, and the largest engraving on steel that has yet been executed.

Mr. Ritchie produced two or three forms of his very convenient new photometer, founded on the principles of Bouguer, an account of which has been read to the Royal Society of Edinburgh.

Mr. Howship laid on the table a beautiful specimen of Burmese art, consisting of a leaf of plantain, on which was written an

edict, or law. The leaf was varnished over; the letters were bold and beautiful in form, and the whole was handsomely gilt in various parts.

Friday, May 26th.—Dr. Harwood read the second part of his paper on the Elephant Genus, which was as before very numerously illustrated by drawings and specimens, with many important additions from the magnificent collection of Mr. Brooks. This communication related to the ancient domestic and present natural history of the *African* species, with observations on the *senses* of elephants generally, and an enumeration of the principal peculiarities in their *structure*. The order of succession in which the subjects were introduced was as follows:—

The intellectual qualities of elephants, curious cellular structure of the head, and consequent difficulty of destruction by ordinary means; great perfection of their sense of *hearing*, and the influence of music on elephants; arrangement of their senses, their supposed antipathies, and instances of their powerful attachment; the geographical distribution, natural character, and ancient employments of the *African* elephant; the trunk of the elephant considered as an exquisite organ of prehension, of smelling, and of feeling; the conditions on which so many useful qualities are combined in it, and its very peculiar muscular apparatus. Observations on the heart, lungs, and liver; the stomach and digestive organs, and excessive capacity of some of the latter; their size in the specimen lately dissected by Mr. Turner; the process of digestion in elephants, and their consumption of food; certain parts of these animals esteemed as delicacies by mankind in all ages. The paper was concluded by further observations on the physical character and natural habits of the present living species (and the *fossil* one, or Siberian mammoth, proposed as a subject for future consideration).

Mr. West produced several models of ancient buildings, as the arch of Constantine, Croyland Abbey, *&c.*, in which not merely were the forms accurately given, but the general aspect and appearance of decay perfectly imitated.

A beautiful model of a conservatory, constructed of iron and glass, was also on the table in the library. It belonged to Mr. Bailey, by whom the original was erected.

June 2nd.—Mr. Solly completed his paper on the Porphyry of Christiania.

Master Noakes, so remarkable for his vivid perception of, and retentive power over, numbers, was present in the library, and performed many calculations, in a manner much to the surprise of those present.

Mr. Leigh sent a rifle of a peculiar construction, which was laid upon the table. The object had been to diminish the weight of the piece as much as possible, and it amounted, indeed, to only $4\frac{1}{2}$ lbs. The length of the barrel was 24 inches. The balls intended for it were of 36 to the lb.

Mr. Frost sent a numerous selection of botanical specimens.

Friday, June 9th.—The subject in the Lecture-Room this evening was the Tunnel at Rotherhithe, now constructing under the Thames by Mr. Brunel. Numerous fine drawings and sections were hung up in the room, and upon the table was a model illustrative of one part of the apparatus now in use; and also some of the smaller parts of the apparatus itself. The principle and proceedings which have advanced the work to its present state were explained from the table by Mr. Faraday, for Mr. Brunel. A tower of brick-work was first erected upon an iron and wooden curb, furnished beneath with a cutting edge; this tower or cylinder was tied together by forty-eight vertical bolts, half iron and half wood, and by thirty-seven horizontal and imbedded wooden hoops. The tower was forty feet high, fifty feet external diameter, three feet thick, required 250,000 bricks, and 1000 barrels of cement, and weighed about 1000 tons. The mode of sinking this cylinder was then described, first, by removing the short piles on which it had been built, and then by taking away the earth from the inside; and the complete command of the tower during its descent explained and illustrated. Being, with the exception of seven feet, sunk into the earth, it

was underpinned for twenty-four feet, and then a second smaller cylinder was lowered in the same manner, at the bottom of the first, for the purpose of a reservoir. This was described, as also the manner in which this enormous shell of brick-work was completed, and was, and is still, preserved from injury by the pressure of the surrounding earth and water; the whole mass weighs about 2000 tons, and, notwithstanding, is buoyant by about 150 tons. The depth from the top to the bottom is about eighty feet. The advantages of this process of sinking the tower consists essentially in dispensing with a coffer-dam, and the consequent diminution of expense; in the comparatively small quantity of ground required on the surface; and in the utter absence of all interference with the neighbouring houses: although surrounded by houses on all sides, within twenty-five feet, not the slightest shake or disturbance has been occasioned.

The horizontal progress was then described, and the peculiar frame-work by which Mr. Brunel makes safe progress in any kind of ground illustrated by large sectional drawings. The section of the brick-work is thirty-six feet six inches by twenty-one feet six inches; and the section of the two ways, each thirteen feet six inches wide, by sixteen feet high. The work has been carried forward 130 feet, the tunnel being completed immediately up to the frames. The numerous accidents of ground, and the manner in which they were met and obviated by the apparatus, were strikingly illustrative of its powers, and the forethought of the contriver; and these were further shewn in the precautions ready for circumstances which have not as yet occurred. Every foot advance requires the removal of forty tons of earth, which has to be replaced by seventeen tons of brick-work, and requires 4000 bricks. It is expected, that when in full working order three feet will be done per day; work having been done up to 30 inches per day with the till now incomplete arrangements; and as much as 100 tons of earth per day having been sent up for a week together.

The evening meetings of the members of the Royal Institution were then adjourned, as had previously been announced, until the ensuing season.

Art. XVII. ASTRONOMICAL AND NAUTICAL COLLECTIONS.—No.XXIII.

i. A Table of Coefficients, *subservient to* Geodetical *Calculations. By the* Editor.

An attempt to arrange a table of fluents, on the plan proposed in the last number of these Collections, has shown that such a table would require to be made extremely voluminous, in order to afford any tolerable uniformity of first differences; so that it would exhibit, in this respect, a striking contrast to the simplicity of Professor Bessel's tables. A short table, of the logarithmic coefficients of the terms of the different series, will, however, be of some use in shortening the computation.

If $P = \int \frac{dx}{\sqrt{(1-xx)}}$, $Q = \int \frac{xxdx}{\sqrt{(1-xx)}}$, $R = \int \frac{x^4dx}{\sqrt{(1-xx)}}$, and so forth, we obtain, by means of the binomial theorem,

$$P = x + \frac{1}{2\,.\,3}x^3 + \frac{1.3}{2.4.5}x^5 + \frac{1.3.5}{2.4.6.7}x^7 + \ldots;$$

$$Q = \frac{1}{3}x^3 + \frac{1}{2.5}x^5 + \frac{1.3}{2.4.7}x^7 + \frac{1.3.5}{2.4.6.9}x^9 + \ldots;$$

$$R = \frac{1}{5}x^5 + \frac{1}{2.7}x^7 + \frac{1.3}{2.4.9}x^9 + \frac{1.3.5}{2.4.6.11}x^{11} + \ldots:$$

$S = \frac{1}{7}x^7 + \frac{1}{2.9}x^9 + \ldots\ldots$; which we may express by making $P = P'x + P''x^3 + P'''x^5 + \ldots$; $Q = Q'x^3 + Q''x^5 + \ldots$; $R = R'x^5 + \ldots$; and so forth.

Logarithmic Coefficients.

Log. P'	= 0·000 000 00	Log. Q'	= 9·522 878 75
P''	= 9·221 848 75	Q''	= 9·000 000 00
P'''	= 8·875 061 26	Q'''	= 8·728 933 22
P''''	= 8·649 751 98	Q''''	= 8·540 607 51
P'''''	= 8·482 615 56	Q'''''	= 8·395 465 39
P''''''	= 8·349 707 89	Q''''''	= 8·277 157 23

Log. R'	$= 9{\cdot}301$	030	00	Log. S'	$= 9{\cdot}154$	901	96
R''	$= 8{\cdot}853$	871	96	S''	$= 8{\cdot}744$	727	49
R'''	$= 8{\cdot}619$	788	76	S'''	$= 8{\cdot}532$	638	58
R''''	$= 8{\cdot}453$	457	34	S''''	$= 8{\cdot}380$	906	67
R'''''	$= 8{\cdot}322$	914	72	S'''''	$= 8{\cdot}260$	766	82

We may take, as an example of this mode of computation, the same case to which Professor Bessel's has already been applied. We have here log. $s = 5{\cdot}478\ 303\ 14$, log. b being 6.513 354 64, and the e^2 of Professor Bessel being not $a^2 - b^2$, but $1 - \frac{bb}{aa}$, we have $\frac{bb}{aa} = 1 - e^2$, and $r^2 = \frac{aa}{\frac{bb}{aa} tt + 1} = \frac{aa}{(1 - ee)\, tt + 1}$, which is equivalent to the $r' = a$ cos. u' of § 3. Professor Bessel's log. of $\sqrt{(1 - e^2)}$, or log. $\frac{b}{a}$, is $= 9{\cdot}998\ 590\ 60$, whence log. $a = 6{\cdot}514\ 764\ 04$, and log. cos. u' being (§ 8) $= 9{\cdot}800\ 326\ 27$, we have log. $r' = 6{\cdot}315\ 090\ 31$, to which adding log. sin. $\alpha' = 9{\cdot}998\ 746\ 62$, we have

log. $g = 6{\cdot}313\ 836\ 93$, whence we find $\chi' = \sqrt{\frac{rr - gg}{aa -}} = \frac{\gamma}{k}$

Log. r^2	$= 12{\cdot}630\ 180\ 62$,	$r^2 =$	4 267 569 600 000
g^2	$= 12{\cdot}627\ 673\ 86$,	$g^2 =$	4 243 008 000 000
a^2	$= 13{\cdot}029\ 528\ 08$,	$a^2 =$	10 703 555 910 000
$r^2 - g^2$	$= 24\ 561\ 600\ 000$		Log. 10·390 256 65
$a^2 - g^2$	$= 6\ 460\ 547\ 910\ 000 = k^2$		12·810 269 34
			2) 7·579 987 31
		Log. $\chi' =$	8·789 993 65

Again, for the western extremity of the curve,

Log. a	$= 6{\cdot}514\ 764\ 04$		
cos. u	$= 9{\cdot}799\ 377\ 50$		
r	$= 6{\cdot}314\ 141\ 54$		
r^2	$= 12{\cdot}628\ 283\ 08$	$r^2 =$	4248 964 200 000
		$g^2 =$	4243 008 000 000
			5 956 200 000

$$\text{Log.}\,r^2-g^2 = 9{\cdot}774\ 969\ 27$$
$$a^2-g^2 = 12{\cdot}810\ 269\ 34$$
$$2)\ 6{\cdot}964\ 699\ 93$$

$$\begin{array}{llll}
\chi & = 8{\cdot}482\ 349\ 96 & \text{Log.}\,\chi' & = 8{\cdot}789\ 993\ 65 \\
\chi^3 & = 5{\cdot}447\ 049\ 89 & \chi'^3 & = 6{\cdot}369\ 980\ 96 \\
\chi^5 & = 2{\cdot}411\ 749\ 82 & \chi'^5 & = 3{\cdot}949\ 968\ 27 \\
\chi^7 & = 9{\cdot}376\ 449\ 75 & \chi'^7 & = 1{\cdot}529\ 955\ 58 \\
P'\chi & = 8{\cdot}482\ 349\ 96 & P'\chi' & = 8{\cdot}789\ 993\ 65 \\
P''\chi^3 & = 4{\cdot}668\ 898 & P''\chi'^3 & = 5{\cdot}591\ 829 \\
P'''\chi^5 & = 1{\cdot}286 & P'''\chi'^5 & = 2{\cdot}825 \\
 & & P''''\chi'^7 & = 0{\cdot}18
\end{array}$$

$$\begin{array}{llll}
P'\chi & = {\cdot}030\ 363\ 369 & P'\chi' & = {\cdot}061\ 658\ 598 \\
P''\chi^3 & = {\cdot}000\ 004\ 665 & P''\chi'^3 & = {\cdot}000\ 039\ 069 \\
P'''\chi^5 & = {\cdot}000\ 000\ 002 & P'''\chi'^5 & = {\cdot}000\ 000\ 067 \\
\hline
P & = {\cdot}030\ 368\ 036 & P & = {\cdot}061\ 697\ 734
\end{array}$$

$$\begin{array}{llll}
\text{Log.}\ Q'\chi^3 & = 4{\cdot}969\ 928\ 64 & \text{Log.}\ Q'\chi'^3 & = 5{\cdot}892\ 859\ 71 \\
Q''\chi^5 & = 1{\cdot}412 & Q''\chi'^5 & = 2{\cdot}950 \\
Q'''\chi^7 & = 8{\cdot}1 & Q'''\chi'^7 & = 0{\cdot}3 \\
Q'\chi^3 & = {\cdot}000\ 009\ 3310 & Q'\chi'^3 & = {\cdot}000\ 078\ 1375 \\
Q''\chi^5 & = {\cdot}000\ 000\ 0026 & Q''\chi'^5 & = {\cdot}000\ 000\ 0891 \\
Q & = {\cdot}000\ 009\ 3336 & & \ {\cdot}000\ 000\ 0002 \\
 & & Q & = {\cdot}000\ 078\ 2268
\end{array}$$

We have now to find $f^2 = \dfrac{aa-gg}{a^4-e^2g^2}\,e^2 = \dfrac{aa-gg}{aa-\dfrac{ee}{aa}gg}\cdot\dfrac{ee}{aa}$:

$\text{Log.}\ \dfrac{ee}{aa} = 7{\cdot}810\ 8710 =$ " Log. e^2, B."

$$g^2 = \frac{12{\cdot}627\ 6739}{10{\cdot}438\ 5449};\quad \frac{ee}{aa}g^2 = 27\ 450\ 476\ 000$$

$$\begin{array}{ll}
a^2 & = 10\ 703\ 555\ 910\ 000 \\
\hline
 & \ 10\ 676\ 105\ 434\ 000
\end{array}$$

$$\begin{array}{ll}
a^2\ \dfrac{ee}{aa}g^2 & = 13{\cdot}028\ 412\ 85 \\
a^2-g^2 & = 12{\cdot}810\ 269\ 34 \\
\hline
 & \ 9{\cdot}781\ 856\ 49 \\
\dfrac{ee}{aa} & = 7{\cdot}810\ 871\ 00 \\
\hline
f^2 & \ 7{\cdot}592\ 727\ 49
\end{array}$$

$$\text{Log. } Q = \begin{cases} 4{\cdot}970\ 048\ 2 \\ 5{\cdot}893\ 355\ 6 \end{cases}$$

$$f^2 Q = \begin{cases} 2{\cdot}562\ 775\ 7 \\ 3{\cdot}486\ 083\ 2 \end{cases} \qquad f^2\ Q = \begin{cases} {\cdot}000\ 000\ 036\ 54 \\ {\cdot}000\ 000\ 306\ 25 \end{cases}$$

$$\tfrac{1}{2} f^2 Q = \begin{cases} {\cdot}000\ 000\ 018\ 27 \\ {\cdot}000\ 000\ 153\ 13 \end{cases}$$

The first term of R gives us log. $R'\chi'^5 = 3{\cdot}25$, and log. $f^4 R = 5{\cdot}185 + 3.25 = 8{\cdot}435$, the number having 11 zeros before it, so that it is quite useless to carry the computations any farther, and we have $P - \frac{1}{2} f^2 Q = {\cdot}030\ 368\ 018$ and ${\cdot}061\ 697\ 581$ respectively, which must be multiplied by $\sqrt{(a^2 - \frac{ee}{aa} g^2)} = h$, for the whole value of s. Thus,

$$\begin{array}{rl} \text{Log. } h = & 6{\cdot}514\ 206\ 42 \\ & 8{\cdot}482\ 417\ 19 \\ & 8{\cdot}790\ 268\ 14 \\ \hline & \begin{cases} 4{\cdot}996\ 623\ 61 \\ 5{\cdot}304\ 474\ 56 \end{cases} \\ \text{Log. } s = & 5{\cdot}478\ 303\ 99 \\ \text{For} & 5{\cdot}478\ 303\ 14 \end{array} \qquad \begin{array}{r} 99225{\cdot}533 \\ 201592.580 \\ \hline 300818{\cdot}113 \end{array}$$

The difference is ·000 000 85, which is equivalent to two parts in a million; and since the error may be in either of the two computations, they may both be supposed, as far as this test goes, to come within one millionth of the truth.

If we proceed to compute the difference of longitude, w, by the second part of the method, it is obvious that we may neglect, in the present case, all but the two first fluents belonging to the value of s, so that we shall have $dw = \frac{d\chi}{\sqrt{(1 - \chi\chi)}} (1 - \frac{1}{2} f^2 \chi^2) \frac{h}{g} (1 - \frac{kk\chi\chi}{gg} + \frac{k^4\chi^4}{g^4} - \frac{k^6\chi^6}{g^6} + \ldots)$, the fluent being $w = \frac{s}{g} - \frac{hkk}{g^3} Q + \frac{hk^4}{g^5} R + \frac{f^2 hk^2}{2g^3} R - \frac{hk^6}{g^7} S - \frac{f^2 hk^4}{2g^5} S + \ldots$

$$\begin{array}{rl} \text{Log. } s = & 4{\cdot}996\ 623\ 61 \\ g = & 6{\cdot}313\ 836\ 93 \\ \hline \frac{s}{g} & 8{\cdot}682\ 786\ 68 \\ \hline Q = & 4{\cdot}970\ 048\ 2 \end{array} \qquad \begin{array}{l} 5{\cdot}304\ 474\ 56 \\ 6{\cdot}313\ 836\ 93 \\ \hline 8{\cdot}990\ 637\ 63 \\ \hline 5{\cdot}893\ 335\ 56 \end{array}$$

$$
\begin{array}{lrl}
\text{Log. } h & = & 6{\cdot}514\ 206\ 42 \\
k^2 & = & 12{\cdot}810\ 269\ 34 \\
g^3,\ \text{A. C.} & = & 81{\cdot}058\ 489\ 21 \\
\hline
 & & 5{\cdot}353\ 013\ 17 \\
\hline
R & = & 1{\cdot}71 \\
\dfrac{hk^4}{g^5} & = & 0{\cdot}56 \\
\cline{3-3}
 & & 2{\cdot}27 \\
\dfrac{s}{g} & = & {\cdot}048\ 171\ 11 \\
 & & \phantom{{\cdot}048\ 171\ 1}2 \\
 & - & {\cdot}000\ 022\ 54 \\
\cline{3-3}
 & & {\cdot}048\ 148\ 59 \\
\cline{3-3}
 & & {\cdot}145\ 827\ 60 \\
 & & {\cdot}139\ 626\ 34 = 8^\circ \\
\cline{3-3}
 & & {\cdot}006\ 201\ 26 \\
 & & {\cdot}006\ 108\ 65 = 21' \\
\cline{3-3}
 & & {\cdot}000\ 092\ 61 \\
 & & {\cdot}000\ 092\ 11 = 19'' \\
\cline{3-3}
 & & {\cdot}000\ 000\ 50 = {\cdot}10
\end{array}
\qquad
\begin{array}{rl}
 & \\
 & {\cdot}3829\ 649\ 7 \\
 & \\
\hline
 & 6{\cdot}276\ 320\ 57 \\
\hline
 & 3{\cdot}25 \\
 & 0{\cdot}56 \\
\cline{2-2}
 & 3{\cdot}81 \\
 & {\cdot}097\ 867\ 30 \\
 & \phantom{{\cdot}097\ 867\ }65 \\
- & {\cdot}000\ 188\ 94 \\
\cline{2-2}
 & {\cdot}097\ 679\ 01
\end{array}
$$

This result exceeds Professor Bessel's computation by $\frac{1}{16}$ of a second, a part of the difference depending on that of the supposed values of s.

In the reduction of short distances to differences of latitude and longitude, it may often be convenient to have a series for expressing χ and w in terms of the distance s and its powers, and we may obtain such series, with any degree of accuracy that may be required, by means of Taylor's theorem; thus,

$\Delta\chi = As + \dfrac{B}{2}s^2 + \dfrac{C}{6}s^3 + \ldots$, and

$\Delta w = A's + \dfrac{B'}{2}s^2 + \dfrac{C'}{6}s^3 + \ldots$; A being the initial value of $\dfrac{d\chi}{ds}$, $B = \dfrac{dA}{ds} = \dfrac{A\,dA}{d\chi}$, $C = \dfrac{dB}{ds}$, and so forth.

We then find, from the equation $ds = h\sqrt{\dfrac{1-f^2\chi^2}{1-\chi^2}}\,d\chi$

$$A = \frac{1}{h}\sqrt{\frac{1-\chi^2}{1-f^2\chi^2}};\ B = \tfrac{1}{2}\frac{d(A^2)}{d\chi} = \frac{f^2\chi(1-{}^2\ )-(1-f^2\chi^2)}{(1-f^2\chi^2)^2}$$

$= - \frac{1-f^2}{(1-f^2x^2)^2 h^2} x$; $C = A \frac{dB}{dx} = - \frac{A}{h^2} \left(\frac{1-f^2}{(1-f^2x^2)^2} + \frac{(1-f^2)\, 4f^2x^2}{(1-f^2x^2)^3} \right) = - \frac{1-f^2}{hh} A \frac{1+3f^2x^2}{(1-f^2x^2)^3}$; $D = A \frac{dC}{dx} = - \frac{1-f^2}{hh} A^2 \frac{6f^2x(1-f^2x^2) + 6f^2x(1+3f^2x^2)}{(1-f^2x^2)^4} + \frac{C}{A} \cdot \frac{AdA}{dx} = \frac{BC}{A} - \frac{1-f^2}{hh} A^2\, 6f^2x \cdot \frac{2+2f^2x^2}{(1-f^2x^2)^4}$; and $E = \frac{dD}{ds} = \frac{A}{dx} dD = \frac{CC}{A} + \frac{BD}{A} - \frac{BBC}{AA} - \frac{1-f^2}{hh}\, 2\,AB\, 6f^2x \cdot \frac{2+2f^2x^2}{(1-f^2x^2)^4} - \frac{1-f^2}{hh} A^3\, 6f^2 \frac{(2+2f^2x^2)}{(1-f^2x^2)^4} + \frac{4f^2x^2(1-f^2x^2)}{(1-f^2x^2)^5} + \frac{8f^2x^2(2+2f^2x^2)}{(1-f^2x^2)^5} = \frac{BD+CC}{A} - \frac{BBC}{AA} - 24\, AB \frac{1-f^2}{hh} f^2x \frac{1+f^2x^2}{(1-f^2x^2)^4} - 12A^3 \frac{1-f^2}{hh} f^2 \frac{1+10f^2x^2+5f^4x^4}{(1-f^2x^2)^5}$.

And for the beginning of the curve, when $x = 0$, we have $A = \frac{1}{h}$ $B = 0$, $D = 0$, $C = - \frac{A}{hh}(1-f^2) = - \frac{1-f^2}{h^3}$; and $E = \frac{CC}{A} - 12\, A^3 \frac{1-f^2}{hh} f^2 = \frac{(1-f^2)^2}{h^5} - \frac{12}{h^5}(f^2 - f^4) = \frac{1-f^2}{h^5}(1-13f^2)$.

The coefficients A', B', C', are computed in the same manner from the equation $dw = \frac{g}{rr} ds$; thus $A' = \frac{dw}{ds} = \frac{g}{rr}$; but $dr = \frac{\gamma d\gamma}{r} = \frac{kk}{r} x dx$, and $\frac{dA'}{ds} = - \frac{2g dr}{r^3 ds} = - \frac{2gkkx}{r^4} \cdot \frac{dx}{ds} = - \frac{2Agkkx}{r^4} = B'$, whence $C' = \frac{dB'}{ds} = \frac{B'}{A} \cdot \frac{dA}{ds} + \frac{B'}{x} \cdot \frac{dx}{ds} - 4 \frac{B'}{r} \cdot \frac{dr}{ds} = - 2gk^2 \left(\frac{Bx}{r^4} + \frac{AA}{r^4} - \frac{4AAkkxx}{r^6} \right)$; and when $x = 0$, $w = \frac{s}{g} - \frac{k^2s^3}{3h^2g^3}$.

The example already employed will serve to illustrate this mode of computation, taking $s = 99225{\cdot}533$.

Log. $\frac{s}{h}$ =	8·482 417 19	$\frac{s}{h}$ =	·030 368 018
$\frac{s^3}{h^3}$ =	5·447 251 57	. . . 6)	·000 028 006
f^2 =	7·592 727 49		·000 004 668
	3·039 979 06		·000 000 110
		$\frac{1-f^2}{6h^3}s^3$	·000 004 650
			·030 363 368 = x.

This agrees very correctly with the value of x from which it was deduced by the former computation, the difference being only a unit in the last place of decimals. The difference of longitude is found by the second series.

Log. s =	4·996 623 61, or		5·304 474 56
s^3 =	14 989 870 83		15·913 423 68
k^2 =	12·810 269 30		80·363 224 42
3	·477 121 25		6·276 648 10
h^2	13·028 412 84		·000 189 08
g^3	18·941 510 79		
	32·447 044 88		
	80·363 224 42	$\frac{s}{g}$	·097 867 30
	5·353 095 25		·097 678 22
	·000 022 55		
$\frac{s}{g}$	·048 171 11		
w =	·048 148 56		

The convergence is here scarcely sufficient, the error being more than $\frac{1}{10}$ of a second in the 8 degrees. But for distances less than a degree, the formula might safely be employed. It will, however, be right to add an example of a portion of the curve not perpendicular to the meridian at its origin; and we may take for this purpose, s = 201592·580 − 99225·533 = 102367·047, log. r being initially 6·31414154, and

Log. x = 8·482 349 96
Log. x^2 = 6·964 699 92
f^2 = 7·592 727 49

$$
\begin{array}{rll}
f^2x^2 = & 4{\cdot}557\ 427\ 41 & \\
1-x^2 = & 9{\cdot}999\ 599\ 30 & \\
1-f^2x^2,\ \text{A.C.} = & {\cdot}000\ 001\ 57 & \\
2) & 9{\cdot}999\ 600\ 87 & \\
 & 9{\cdot}999\ 800\ 43 & \\
\frac{1}{h} = & 3{\cdot}485\ 793\ 58 & \\
\Delta s = & 5{\cdot}010\ 160\ 18 & \\
 & 8{\cdot}495\ 754\ 19\ \ldots & {\cdot}031\ 315\ 128 \\
\frac{1-x^2}{1-f^2x^2} = & 9{\cdot}999\ 600\ 87 & \\
(1-f^2x^2)h^2 & 13{\cdot}028\ 411\ 27 & \\
 & 86{\cdot}971\ 189\ 60 & \\
x = & 8{\cdot}482\ 349\ 96 & \\
\Delta s^2 = & 10{\cdot}020\ 320\ 36 & \\
 & 5{\cdot}473\ 859\ 92\ \ldots & {\cdot}000\ 029\ 776 \\
 & -\tfrac{1}{2} & {\cdot}000\ 014\ 888 \\
A = & 3{\cdot}485\ 594\ 01 & \\
1+6f^2x^2 = & {\cdot}000\ 009\ 42 & \\
1-f^2 = & 9{\cdot}998\ 296\ 50 & \\
\frac{1}{hh} = & 86{\cdot}971\ 587\ 16 & \\
\Delta s^3 = & 15{\cdot}030\ 480\ 54 & \\
 & 5{\cdot}485\ 967\ 63\ \ldots & {\cdot}000\ 030\ 618 \\
 & -\tfrac{1}{6} & {\cdot}000\ 005\ 103 \\
 & & {\cdot}000\ 019\ 991 \\
 & \Delta x = & {\cdot}031\ 295\ 137 \\
 & & {\cdot}030\ 363\ 369 \\
 & x = & {\cdot}061\ 658\ 506
\end{array}
$$

This differs from the truth by about two parts in a million.

The computation of the difference of longitude may be considerably facilitated by first finding the latitude of the middle point

of the arc, and then computing the difference of the values of w for $\frac{1}{2}s$ and $-\frac{1}{2}s$, since in this manner the alternate terms of the series are made to vanish, and the odd powers only of s are retained. Thus, for the portion of the arc last calculated, we find at the middle point $\Delta\chi = \cdot 015\ 657\ 564 - \cdot 000\ 003\ 722 - \cdot 000\ 000\ 638 = \cdot 015\ 653\ 204$, and the new value of $\chi = \cdot 046\ 016\ 573$, whence, $\frac{1}{2}s$ being 51183·5235,

Log. $\chi =$	8·662 7736	$1-\chi^2 =$	9·999 0800
$\chi^2 =$	7·325 5472	$f^2 =$	7·592 7275
$k^2 =$	12·810 2693	$f^2\chi^2 =$	4·918 2747
$\gamma^2 =$	10·135 8165	$1-f^2\chi^2 =$	9·999 9960
$g^2 =$	12·627 6739		
"B", Matthiesen	·001 3971	$\frac{1}{hh} =$	86·971 5872
$r^2 =$	12·629 0710	$A^2 =$	86·970 6712
A. C. $=$	87·370 9290	$g =$	6·313 8369
$g =$	6·313 8369	$k^2 =$	12·810 2693
$s =$	4·709 1302	$\frac{1}{r^4} =$	74·741 8580
	8·393 8961	$s^3 =$	14·127 3906
$\frac{gs}{rr} =$	·024 76830		4·964 0260
	·000 00307		3) ·000 00920
	·024 76523		·000 00307
	·049 53046		
	·049 53042		

The difference of 2 in the last place of figures would nearly disappear if we considered the other parts of the coefficient C'; but the term containing A^2 will be sufficient for common purposes, making

$$\Delta w = \frac{g\Delta s}{rr} - \frac{gkk\Delta s^3}{3h^2r^4}(1 - \chi^2 + f^2\chi^2).$$

ii. *Estimate of the effect of the Terms involving the* SQUARE *of the disturbing* FORCE *on the Determination of the* FIGURE *of the* EARTH. *In a Letter to* G. B. AIRY, Esq.

My dear Sir,

I ventured to express to you the other day my opinion, that the terms depending on the square of the force might safely be neglected in our investigations relating to the figure of the earth; and I shall now state more particularly the reasoning on which my estimate is founded, taking as an example the case which we mentioned, of a fluid, supposed to be without weight, and surrounding a spherical nucleus. In this case I apprehend that the consideration of the square of the force will make no difference whatever in the excess of the equatorial diameter above the axis, but that the semidiameter bisecting the angle formed by those lines will be *shortened* by one *half* of the *square* of the ellipticity; that is, for a body of the magnitude of the earth, by about thirty feet.

Calling a minute centrifugal force at the equator f, the force of gravitation there being unity, the immediate centrifugal force elsewhere will be expressed by $f \cos. \varphi$, φ being either the force, or more correctly, the reduced latitude, which has also been called the geocentric latitude, and might be named with more minute propriety *centrocentric;* and the same force, reduced to a horizontal direction, will be $f \sin. \cos. \varphi$. Again, the excess of the equatorial semidiameter above the semiaxis 1 being ε, the elevation above the inscribed sphere will be everywhere $\varepsilon \cos.^2 \varphi$, consequently the inclination to the spherical surface, or its tangent, will be $\varepsilon \dfrac{d \cos.^2 \varphi}{d \varphi}$ $= -2\varepsilon \sin. \cos. \varphi$, which expresses the force of gravitation reduced to the direction of the surface, and which must be equal to $f \sin. \cos. \varphi$, so that we have $2\varepsilon = f$, when both are evanescent. When they are still small, but not evanescent, we must compute

the amount of two perturbations; the first arising from the inclination of the surface, which makes the sine of the angle in the proportion of which the force f is to be reduced, not that of the geocentric, but that of the true latitude; that is, not sin. φ, but sin. φ + cos. φ 2ε sin. cos. φ; and in order to counteract this perturbation and to preserve the equilibrium, we must have an additional inclination equivalent to $-f$ cos.$^3\varphi$ 2ε sin. φ, or to $-f^2$ cos.$^3\varphi$ sin. φ. In the second place, the supposed inclination will require to be modified, on account of the variation of the force of gravity depending on the distance from the centre, a variation amounting everywhere to 2ε sin.$^2\varphi$, which is the measure of twice the depression below the circumscribed sphere, so that the tangent, instead of f sin. cos. φ, must become $-f$ sin. cos. φ $(1-f$ sin.^{2} $\varphi)$, the alteration being $= f^2$ sin.^{3} φ cos. φ. The sum of the fluents of these two corrections, which are respectively $\frac{1}{4}f^2$ cos.$^4\varphi$, and $\frac{1}{4}f^2$ sin.$^4\varphi$, shews the elevations, which, at the equator and at the poles, are simply $\frac{1}{4}f^2$; and being equal, do not affect the magnitude of the ellipticity. But cos.$^4\varphi$ + sin.$^4\varphi = \frac{3}{4} + \frac{1}{4}$ cos. 4φ, the fluxion of which is also expressed by $-$ sin. $4\varphi d\varphi$, and the second fluxion by $-$ 4 cos. $4\varphi d\varphi^2$, so that a curvature of f^2 cos. 4φ is to be everywhere added to that of the elliptic arc, the curvature of the inscribed sphere being unity; and it is evident that within one fourth of a right angle of the equator and of the poles, this minute quantity will increase the curvature, and diminish it at the intermediate latitudes; the elevation added being always $\frac{3}{16}f^2$ + $\frac{1}{16}f^2$ cos. 4φ, or $\frac{3}{4}\varepsilon^2 + \frac{1}{4}\varepsilon^2$ cos. 4φ; the utmost variation being $\frac{1}{2}\varepsilon^2$ or $\frac{1}{8}f^2$, and f being $\frac{1}{289}$; so that it can nowhere exceed $\frac{1}{667000}$.

Since, therefore, it is found that in the two extreme cases of a uniform density, and an infinite difference of density between the surface and the central parts, the equilibrium is obtained in a figure not sensibly differing from an elliptic spheroid, it may safely be concluded that the ellipsis will sufficiently answer the conditions of equilibrium in intermediate constitutions of the internal parts of the earth.

T. Y.

iii. REFRACTIONS *observed in high* LATITUDES, *in a Letter to the Editor, from the Rev.* GEORGE FISHER.

23rd Feb. 1826.
Wansted Vicarage, Essex.

Dear Sir,

I have enclosed some of the observations upon the refraction at low temperatures and altitudes, made at the island of Igloolik, N.E. coast of America. And as the law of variation in the temperature of atmosphere at different heights is connected with the theoretical investigation of the subject, I take the opportunity of mentioning an experiment made by Captain Parry and myself, for determining it.

This was done by means of a paper kite, to which was attached an excellent register thermometer, in a horizontal position. Its height above the level of the frozen sea, upon which the experiment was made, was determined by two observers in the same vertical plane, taking its altitude at the same time above the distant horizon; and from thence its height was computed. The greatest height observed was 379 feet, at which height it was nearly stationary for about a quarter of an hour. It probably, however, had been more than 400 feet above the sea. After an unsuccessful attempt, the experiment was made under very favourable circumstances, the kite being sent up and caught in coming down, without the slightest shake. The indices had not altered their position in the slightest degree, and they would have indicated any variation of temperature, had it existed, to less than a quarter of a degree, Fahr. The temperature at the time was — 24° Fahr.

I have also enclosed Dr. Brinkley's table of refractions, adapted to temperatures as low as — 50° Fahr., which he was kind enough to send me.

From, dear Sir,
Your's truly,
GEO. FISHER.

SOLAR REFRACTIONS, at low Temperatures and Altitudes, observed at the Island of Igloolik, Lat. 69° 21′ N. Long. 81° 42′ W.

	App. Alt.	Obs. Refr.	Ther. Fahr.	Bar.		REMARKS.
1822	° ′ ″	° ′ ″	°			
Nov. 25	0 26 45	0 49 52	−32	29.62	L. Limb	On the Mer., with Cary's Alt. & Azim. Instr.
28	0 26 10	0 50 19	−34	29.50	Upp. ”	ditto
29	0 22 30	0 57 2	−28	29.70	”	ditto
1823						
Jan. 23	0 8 40	1 21 19	−28	30.11	”	⊙ to the S. E. with Cary's Instrum.
”	0 10 40	1 13 23	−28	30.11	”	ditto
”	0 15 0	1 3 2	−28	30.11	”	ditto
”	0 22 0	0 59 55	−28	30.11	”	ditto
”	0 26 40	0 55 29	−28	30.11	”	ditto
”	0 28 22	0 54 22	−28	30.11	L. Limb	ditto
”	0 40 2	0 44 33	−28	30.11	”	ditto
”	0 50 2	0 39 47	−28	30.11	”	ditto
25	0 12 20	1 2 53	−30	30.37	Upp. ”	ditto
”	0 18 40	0 56 19	−30	30.37	”	ditto
”	0 26 20	0 50 46	−30	30.37	”	ditto
”	0 17 2	1 0 19	−30	30.37	L. ”	ditto
”	0 39 0	0 41 20	−30	30.37	Upp. ”	ditto
”	0 24 22	0 48 10	−30	30.37	L. ”	ditto
”	0 39 22	0 42 2	−30	30.37	”	ditto
Feb. 18	0 12 22	0 53 0	−27	29.67	”	ditto
	0 29 52	0 42 52	−27	29.67	”	ditto
	0 51 12	0 35 53	−27	29.67	”	ditto
19	0 16 2	0 59 52	−40	29.80	”	ditto
”	0 51 0	0 40 12	−40	29.80	Upp. ”	ditto
”	0 37 12	0 47 4	−40	29.80	L. ”	ditto
”	0 51 2	0 38 33	−40	29.80	”	ditto
(The above are all the observations which could be obtained at altitudes below 1° at temp. below −20°).						
”	9 39 1	0 6 58.4	−38½	29.79	Upp. L.	On the Mer. with Rep. Circ. 5 Rep. −28° in ⊙.
20	9 27 28	0 6 42.4	−27½	29.64	L. ”	ditto −23 in ⊙.
21	9 48 44	0 6 21.9	−19	29.50	”	Ditto, (brilliant halo round ⊙).
22	10 10 17	0 5 56.0	−13	29.48	”	Ditto R. Circle, 6 Repet.
23	10 31 50	0 5 53.2	−23	29.67	”	ditto −19 in ⊙.
24	10 53 59	0 5 50.7	−27	29.79	”	ditto −16 ”
25	11 26 26	0 5 49.6	−37	29.83	”	ditto −22 ”
26	11 38 24	0 5 20.0	−19	29.46	”	Ditto (Halo round ⊙) −18 ”
27	12 0 22	0 5 29.4	−30	29.94	”	ditto −27 ”
28	12 22 59	0 5 14.5	−35	29.98	”	ditto −31 ”
Mar. 1	13 18 1	0 5 2.1	−36	29.73	Up. ”	ditto −32 ”
2	13 8 0	0 4 54.3	−35	29.70	L. ”	Ditto (Halo round ⊙) −24 ”
3	14 3 27	0 4 41.5	−33	29.92	Up. ”	ditto −24 ”
4	13 53 44	0 4 45.0	−37	30.10	L. ”	8 Rep. with circle on Mer. −24 ”
10	16 12 27	0 3 49.1	−21	29.81	”	ditto −16 ”
12	17 32 19	0 3 42.9	−22	29.96	Up. ”	ditto − 8 ”
13	17 23 4	0 3 30.6	−16	29.90	L. ”	ditto − 8 ”
14	18 19 9	0 3 27.0	−10	29.72	Up. ”	ditto +18 ”
15	18 10 16	0 3 16.7	−14	29.98	L. ”	ditto − 5 ”
16	19 6 20	0 3 30.2	−23	30.50	Up. ”	ditto −10 ”
17	18 57 40	0 3 16.7	−17	30.77	L. ”	ditto −14 ”
18	19 53 27	0 3 22.2	−18	30.72	Up. ”	ditto, (very variable)
19	19 44 51	0 3 2.4	− 6	30.38	L. ”	Do. ther. in ⊙ sheltered from the wind + 44½
20	20 40 30	0 3 2.7	− 7	30.10	Up. ”	
21	20 30 58		− 4	30.06	L. ”	ditto +12 ”
22	21 28 13	0 2 55.3	− 2	30.00	Up. ”	ditto +22 ”
24	21 42 47	0 2 38.7	− 6	30.00	L. ”	ditto +10 ”
26	23 1 37	0 2 37.1	− 6	29.90	Up. ”	ditto +12 ”
28	23 48 9	0 2 37.1	−13	30.00	”	ditto
29	24 12 4	0 2 33.7	−13	29.91	”	ditto
30	24 35 54	0 2 25.8	−11	30.08	”	ditto
May 30	1 18 56	0 25 5.2	+12	30.13	L. ”	
June 2	1 41 31	0 22 32.3	+14	30.31	”	Observed below the Pole on Mer.
23	2 48 29	0 16 6.9	+33	30.33	”	

SIDEREAL REFRACTIONS at low Temperatures and Altitudes.

	App. Alt.	Obs. Ref.	Ther. Fahr.	Bar.		REMARKS.
	° ′ ″	° ′ ″	°			
Mar. 10	0 29 25	0 40 29	−28	30.00		Mean of 7 obs. E. of the Mer. (upon Sirius.
,,	0 43 14	0 36 24.8	−28	30.00		ditto
,,	0 58 49	0 32 4	−28	30.00		ditto
18	0 58 22	0 33 26.5	−20	30.60		ditto
,,	0 45 33	0 37 23.1	−20	30.60		ditto
,,	0 30 55	0 42 8.4	−20	30.60		ditto
Jan. 20	0 50 53	0 38 7.7	−22	29.83		ditto

The above observations were all that could be obtained at altitudes lower than 1°, and at temperatures below −20° Fahr. The following were made with the repeating circle

	App. Alt.	Obs. Ref.	Ther. Fahr.	Bar.		REMARKS.
Jan. 19	4 23 8	0 13 0.0	−20	29.67		* in Aur. Bor. with rep. cir. E. of Me
31	3 21 9	0 15 40.8	−23	29.82		Star East of Meridian.
,,	4 22 23	0 12 54.9	−23	29.82		Star on the Meridian.
Feb. 5	2 35 31	0 18 1.3	−13	30.26		Star in Aurora.
,,	3 16 35	0 15 33.1	−13	30.26		ditto
,,	4 10 56	0 13 24.3	−13	30.26		ditto
,,	4 22 50	0 12 48.2	−13	30.26		Star in brilliant Aurora. On Meric
16	3 49 44	0 15 1.8	−45	29.32		
,,	4 0 19	0 14 56.5	−45	29.32		
,,	4 9 8	0 14 43.2	−45	29.32		
,,	4 19 42	0 14 13	−45	29.32		
18	3 19 16	0 16 12.3	−39	29.73		
,,	3 41 1	0 15 27.0	−39	29.73		
,,	4 7 20	0 13 58.1	−39	29.73		
,,	4 18 36	0 13 38.3	−39	29.73		
,,	4 22 54	0 13 46.8	−39	29.73		Observed on the Meridian.
21	4 23 5	0 13 8.7	−23	29.50		ditto
24	4 21 59	0 13 34 3	−37	29.82		ditto
27	4 23 31	0 14 10.2	−43	30.20		ditto
Mar. 10	4 23 9	0 13 16.2	−27	29.95		ditto
18	3 20 46	0 17 16.0	−24	30.65		Star West of Meridian.
,,	3 7 34	0 17 25.7	−24	30.65		ditto
,,	2 54 56	0 18 20.3	−24	30.65		ditto
,,	4 22 55	0 13 1.6	−21	29.84		Mean of 5 Mer. observ. with rep. ci
,,	4 21 21	0 13 52.5	−40.6	29.76		ditto
Jan. 29	12 18 57	0 4 49.5	−14	29.29	Rigel	Meridian observations 3 repetitions
Feb. 21	12 18 8	0 4 57.4	−23	29.50	,,	Ditto 4 ditto.
24	12 18 20	0 5 4.6	−37	29.82	,,	Ditto ditto.
27	12 18 27	0 5 9.5	−43	30.00	,,	Ditto 6 ditto.
Mean of above 4	12° 18′ 28″	0° 5′ 0.2″	−29¼°	29.90		

Observation.—The North Polar distances of the Sun and Stars were taken from t Nautical Almanac, and the latitude used in computing the refractions was determined observations of high Stars above and below the Pole with a 12 inch repeating circle Troughton.

The solar declinations, in the Connaissance des Tems, are 1″ less than those given in t Nautical Almanack for March, 1823, and in the following June, no less than 3′ less, wh reduced to the same meridian.

Dr. Brinkley's Tables of Refractions.

Table I.

Z. Dist.	Log.	Diff. for 1.
80° 0′	1.3605	6.90
81 0	1.4031	7.62
82 0	1.4488	8.21
83 0	1.4981	9.07
84 0	1.5524	10.13
85 0	1.6132	11.00
85 30	1.6462	11.37
86 0	1.6803	12.07
86 30	1.7165	13.23
87 0	1.7562	13.75
87 20	1.7837	14.55
87 40	1.8128	14.65
88 0	1.8421	15.50
88 20	1.8731	16.05
88 40	1.9052	16.75
89 0	1.9387	17.25
89 20	1.9732	18.00
89 40	2.0092	18.60
90 0	2.0464	

Table II.

Fahr. Ther.	Log.	Ther.	Log.	Ther.	Log.	Ther.	Log.
−50°	0.3917	−17°	0.3556	+16°	0.3223	+49°	0.2910
−46	0.3905	−16	0.3545	+17	0.3213	+50	0.2900
−48	0.3893	−15	0.3534	+18	0.3203	+51	0.2891
−47	0.3882	−14	0.3524	+19	0.3193	+52	0.2881
−46	0.3871	−13	0.3514	+20	0.3183	+53	0.2872
−45	0.3860	−12	0.3504	+21	0.3173	+54	0.2863
−44	0.3849	−11	0.3494	+22	0.3163	+55	0.2854
−43	0.3838	−10	0.3484	+23	0.3154	+56	0.2845
−42	0.3827	− 9	0.3473	+24	0.3144	+57	0.2836
−41	0.3816	− 8	0.3462	+25	0.3134	+58	0.2827
−40	0.3805	− 7	0.3452	+26	0.3124	+59	0.2818
−39	0.3794	− 6	0.3442	+27	0.3114	+60	0.2809
−38	0.3783	− 5	0.3432	+28	0.3105	+61	0.2800
−37	0.3772	− 4	0.3422	+29	0.3095	+62	0.2791
−36	0.3761	− 3	0.3412	+30	0.3086	+63	0.2782
−35	0.3750	− 2	0.3402	+31	0.3076	+64	0.2773
−34	0.3739	− 1	0.3392	+32	0.3067	+65	0.2764
−33	0.3728	− 0	0.3382	+33	0.3058	+66	0.2755
−32	0.3717	+ 1	0.3372	+34	0.3048	+67	0.2746
−31	0.3706	+ 2	0.3362	+35	0.3039	+68	0.2737
−30	0.3696	+ 3	0.3352	+36	0.3030	+69	0.2728
−29	0.3685	+ 4	0.3342	+37	0.3020	+70	0.2720
−28	0.3674	+ 5	0.3332	+38	0.3011	+71	0.2711
−27	0.3663	+ 6	0.3322	+39	0.3001	+72	0.2703
−26	0.3652	+ 7	0.3312	+40	0.2992	+73	0.2694
−25	0.3641	+ 8	0.3302	+41	0.2983	+74	0.2685
−24	0.3630	+ 9	0.3292	+42	0.2974	+75	0.2677
−23	0.3619	+10	0.3283	+43	0.2965	+76	0.2668
−22	0.3609	+11	0.3273	+44	0.2956	+77	0.2660
−21	0.3599	+12	0.3263	+45	0.2946	+78	0.2652
−20	0.3589	+13	0.3253	+46	0.2937	+79	0.2644
−19	0.3578	+14	0.3243	+47	0.2928	+80	0.2636
−18	0.3567	+15	0.3233	+48	0.2919	+81	0.2627

TABLE III.

Therm. near Barom.	Log.
−50	0.2944
−40	0.2930
−30	0.2935
−20	0.2931
−10	0.2926
0	0.2922
+10	0.2917
+20	0.2913
+30	0.2909
+40	0.2904
+50	0.2900
+60	0.2896
+70	0.2891
+80	0.2887

TABLE IV.—*Barometer.*

Z. D.	28.50	29.00	29.50	30.00	30.50
80	10.5	10.7	10.9	11.1	11.4
79	8.1	8.3	8.5	8.7	8.9
78	6.3	6.4	6.6	6.7	6.9
77	5.1	5.2	5.3	5.4	5.6
76	4.1	4.2	4.3	4.4	4.5
75	3.4	3.4	3.5	3.6	3.7
74	3.0	3.0	3.1	3.1	3.2
73	2.5	2.5	2.6	2.6	2.6
72	2.1	2.1	2.2	2.2	2.2
71	1.8	1.8	1.9	1.9	1.9
70	1.5	1.6	1.6	1.6	1.6
69	1.3	1.4	1.4	1.4	1.4
68	1.2	1.2	1.2	1.2	1.2
67	1.0	1.0	1.0	1.0	1.0
66	0.9				
65	0.8				
64	0.7				
63	0.6				
62	0.6				
61	0.5				
60	0.5				
58	0.4				
56	0.3				
54	0.3				
52	0.2				
50	0.2				
45	0.2				
40	0.1				
30	0.0				

Use of Table IV. for Z. distances less than 80°.
Log. tan. *ZD* + log. barom. + log. in Table II. = app. refr.
True refr. = app. refr. − Tab. IV.

Example		
	Z. dist. tan.	10.3874
Z dist. 67° 43′	Bar. log.	1.4610
Bar. 28.91 ther. 63°	Therm. Tab. II.	0.2782
	133.″9 log.	2.1266
	2.13.9 app. refr.	
	1.1	
	2.12.8 True refraction.	

Use of the Tables I, II, and III, for Altitudes below 10°.

Log. *A* in minutes of a degree = Tab. I. + ar. comp. Tab. II. + Tab. III.
Log. *B* in minutes = Tab. I. + Tab. II. + log. barom. + 7.2773.
Log. Refraction in seconds = Tab. II. + log. barom. + log. tan. (zen. dist. − *A* + *B*).

EXAMPLE I.

	° ′ ″	
App. altitude	4 21 20	Bar. 29.76. Therm. − 41°.
Zenith distance	85 38.67	

Tab. I.	1.6561		Tab. I.	1.6561
Ar. comp. Tab. II.	9.6184		Tab. II.	0.3816
Tab. III.	0.2939		Log. bar.	1.4736
A, − 37.02	log. 1.5684		Const.	7.2773
B, + 6.15			*B*, + 6.15	0.7886
− 30.87				
85 38.67				
85 7.80	tan. 11.0695			
Tab. II.	0.3816			
Log. barom.	1.4736			
840″.8	log. 2.9247			
14′ 0″.8	comp. refraction.			
13 52.5	observed.			
+ 8.3	error.			

EXAMPLE II.

	° ′ ″	
App. alt.	0 29 25	Bar. 30.00. Therm. − 28°.
Zenith distance	89 30 58	

Tab. I.	1.9922		Tab. I.	1.9922
Ar. comp. Tab. II.	9.6326		Tab. II.	0.3674
Tab. III.	0.2934		Log. bar.	1.4771
A, − 82.83	log. 1.9182		Const.	7.2773
B, + 13.00			*B*, + 13.00 log.	1.1140
− 69.83				
89 30.58				
88 20.75	tan. 11.5394			
Tab. II.	0.3674			
Log. barom.	1.4771			
2420″,5	Log. 3.3839			
40′ 20″.5	comp. refraction.			
40′ 29″.0	observed.			
− 8.5	error.			

[It has been thought the more eligible to reprint these Tables, with the extension to very low temperatures, as the form, in which they appear in Professor Schumacher's first Number of Auxiliary Tables, for 1820, is liable to some misconstruction. EDITOR.]

iv. *Observations of* REFRACTION *in Latitude* 73°. *By Lieutenant* HENRY FOSTER, R. N.

Observations for the Atmospheric Refraction, observed by the disappearance of Arctu[illegible]

Day	Time of Arcturus setting by No. 423	Transit observed. Star	Transit observed. Time by 423	Rate of 423	Arcturus Hor. ∠ at setting	Arcturus True Altitude	Observed Refraction	Tables in Defect	A[illegible] Te[illegible] +4[illegible] Ba[illegible]
	h ′ ″		h ′ ″	″	h ′ ″	° ′ ″	′ ″	″	In[illegible]
Nov. 28	12 54 38	α Andromedæ	13 36 52.58	+2.8	9 9 20.93	7 27 9.62	8 8.81	27.77	29.[illegible]
Dec. 1	12 43 2	α Arietis	15 22 52.44	+1.72	9 9 24.33	7 26 59.34	8 19.09	22.67	30.[illegible]
2	12 39 7.5	ditto	15 18 58.34	+2.83	9 9 24.12	7 26 58.31	8 20.22	24.80	29.[illegible]
4	12 31 20	ditto	15 11 15.53	+4.0	9 9 19.50	7 27 11.94	8 6.49	14.79	29.[illegible]
5	12 27 41	α Andromedæ	13 9 43.56	+3.94	9 9 32.76	7 26 34.84	8 43.59	48.13	29.[illegible]
6	12 23 44	ditto	13 5 50.51	+3.9	9 9 28.77	7 26 45.65	8 32.78	41.48	29.[illegible]
7	12 19 45	ditto	13 1 58.45	+3.9	9 9 21.77	7 27 4 89	8 13.54	32.87	29.[illegible]
8	12 15 55	ditto	12 58 6.65	+3.6	9 9 23.53	7 26 59.68	8 18.75	30.81	29.[illegible]
9	12 12 06	ditto	12 54 14.86	+4.23	9 9 26.31	7 26 51.70	8 26.73	36.59	29.[illegible]
13	12 10 50.5	ditto	12 52 54.70	+4.00	9 9 30.92	7 26 37.90	8 40.53	41.24	30.[illegible]
	Time by 649		Time by 649	ra.649					
14	12 6 58	ditto	12 49 4.70	+6.4	9 9 28.35	7 26 44.78	8 33.65	29.95	30.[illegible]
15	12 3 10.5	ditto	12 45 13.63	+5.4	9 9 31,84	7 26 34.51	8 43 92	30.66	30.[illegible]
21	11 40 5	ditto	12 22 8.75	+6.2	9 9 31.01	7 26 35.60	8 42.83	42.94	29.[illegible]
22	11 36 12.2	ditto	12 18 16.95	+4.4	9 9 29.90	7 26 38.44	8 39.99	38.40	29.[illegible]
23	11 32 21	ditto	12 14 25.46	+4.2	9 9 30.15	7 26 37.47	8 40.96	38.63	29.[illegible]
25	11 24 33.5	dtito	12 6 40.75	0.0	9 9 27.13	7 26 45.36	8 32.07	33.74	29.[illegible]
26	11 20 41.5	ditto	12 2 50.33	+5.2	9 9 25.68	7 26 49.10	8 29 33	25.75	29.[illegible]
28	11 12 52	ditto	11 55 7.36	+1.3	9 9 18.92	7 27 7.45	8 10.58	28.65	29.[illegible]
29	11 9 3.5	ditto	11 51 15.45	+2.8	9 9 22.34	7 26 57.60	8 20.83	33.67	29.[illegible]
Jan. 2	10 53 44	ditto	11 35 51.95	+5.0	9 9 26.20	7 26 45.18	8 33.25	31.25	29.[illegible]
3	10 49 51.5	α Arietis	13 29 41.00	0.0	9 9 23.68	7 26 52.06	8 26.37	23.14	29.[illegible]
4	10 46 00.8	α Andromedæ	11 28 9.42	+3.8	9 9 25.41	7 26 37.37	8 41.06	46.47	29.[illegible]
5	10 42 15.5	ditto	11 24 17.63	+4.3	9 9 31.88	7 26 28.74	8 49.69	48.89	29.[illegible]
7	10 34 26	ditto	11 16 34.10	+4.0	9 9 25.80	7 26 45.15	8 33.28	30.98	29.[illegible]
10	10 22 59.5	ditto	11 5 2.93	+5.6	9 9 30.39	7 26 31.73	8 46.70	38.16	29.[illegible]
11	10 19 10	ditto	11 1 11.25	+4.0	9 9 32.56	7 26 25.33	8 53.10	39.61	30.[illegible]
12	10 15 20.5	ditto	10 57 20.23	+4.9	9 9 34.29	7 26 20.50	8 57.93	46.84	29.[illegible]
15	10 3 43.5	ditto	10 45 45.85	+4.5	9 9 31.21	7 26 28.53	8 49.90	51.94	29.7[illegible]
16	9 59 49	ditto	10 41 55,78	+6.2	9 9 26.78	7 26 40.64	8 37.79	36.01	29.7[illegible]
17	9 55 58	ditto	10 38 4.91	+5.7	9 9 26.58	7 26 41.00	8 37.43	40.03	29.[illegible]
20	9 44 21	α Pegasi	9 23 24.07	+5.4	9 9 21.55	7 26 54.42	8 24.01	31.37	29.4[illegible]
22	9 36 35	ditto α Andromedæ	9 15 43.05 10 18 51.20	+5.84	9 9 16.77	7 27 7.39	8 11.04	19.97	29.[illegible]
24	9 29 12	α Pegasi	9 8 2.18	+3.87	9 9 35.02	7 26 16.21	9 2.22	54.12	29.[illegible]
25 27	9 25 15	α Andromedæ α Pegasi	10 11 9.56 9 4 11.47	+5.5	9 9 27.98	7 26 35.77	8 42.66	30.46	29.77
	9 17 28.5	ditto	8 56 30.00	+6.2	9 9 22.85	7 26 49.70	8 28.73	29.34	29.8[illegible]
Feb. 2	8 54 25.5	α Andromedæ	9 36 29.55	+3,84	9 9 28.74	7 26 32.54	8 45.89	30.00	30.1[illegible]
10	8 23 26.5	ditto	9 5 32.53	+4.00	9 9 26.47	7 26 38.02	8 40.41	27.10	30.2[illegible]
						Means	8 36.36	34.57	29.8[illegible]

Observations for the Atmospheric Refraction, observed by the disappearance of Arctu[illegible]

Day	Time of Arcturus setting	Star	Time	Rate	Hor. ∠ at setting	True Altitude	Observed Refraction	Tables in Defect	[illegible]
	h ′ ″		h ′ ″	″	h ′ ″	° ′ ″	′ ″	″	In[illegible]
Dec. 21	11 39 19	α Andromedæ	12 22 8.75	+6.2	9 8 44.91	7 28 43.83	8 24.31	25.88	29.[illegible]
22	11 35 35.5	ditto	12 18 16.96	+4.4	9 8 53.1	7 28 20.76	8 47.38	47.26	29.[illegible]
23	11 31 42.5	ditto	12 14 25.46	+4.2	9 8 51.5	7 28 24.94	8 43.20	42.33	29.[illegible]
25	11 23 56	ditto	12 6 40.75	0.0	9 8 49.53	7 28 29.92	8 38.22	41.85	29.[illegible]
26	11 20 01	ditto	12 2 50.33	+5.2	9 8 45.07	7 28 42.10	8 26.04	25.44	29.[illegible]
Jan. 2	10 53 3.2	ditto	11 35 51.95	+5.0	9 8 45.29	7 28 38.93	8 29.16	28.63	29.[illegible]
3	10 49 11.5	α Arietis	13 29 41	0.0	9 8 43.57	7 28 43.75	8 24.39	22.62	29.[illegible]
5	10 41 34.5	α Andromedæ	11 24 17.63	+4.3	9 8 50.77	7 28 23.04	8 45.10	45.77	29.[illegible]
7	10 33 49.2	ditto	11 16 34.10	+4.0	9 8 48.90	7 28 28.56	8 39.58	38.79	29 5[illegible]
10	10 22 19	ditto	11 5 2.93	+5.6	9 8 49.78	7 28 24.88	8 43.26	36.19	29 [illegible]
11	10 18 34	ditto	11 1 11.25	+4.0	9 8 56.46	7 28 5.68	8 52.46	40.43	30.1[illegible]
12	10 14 38.5	ditto	10 57 20 23	+4.9	9 8 52.17	7 28 17.63	8 50.51	40.88	29.[illegible]
15	10 03 00	ditto	10 45 45.85	+4.5	9 8 47.59	7 28 29.82	8 38.32	41.82	29.7[illegible]
16	9 59 09	ditto	10 41 55.78	+6.2	9 8 46.67	7 28 32.18	8 35.96	35.64	29.7[illegible]
17	9 55 17	ditto	10 38 4.91	+5.07	9 8 45.47	7 28 35.35	8 32.79	36.85	29.6[illegible]
20	9 43 40.8	α Pegasi	9 23 24.07	+5.4	9 8 41.24	7 28 46.67	8 21.57	30.40	29.4[illegible]
22	9 35 57	α Pegasi α Andromedæ	9 15 43.05 10 18 51.2	+5.84	9 8 38.67	7 28 53.44	8 14.70	25 09	29.3[illegible]
24	9 28 32	α Andromedæ	10 11 9.56	+3.87	9 8 54.91	7 28 7.88	9 00.26	53.63	29.8[illegible]
25	9 24 37.8	α Pegasi α Pegasi	9 8 2.18 9 4 11.47	+5.5	9 8 50.68	7 28 19.51	8 48.63	37.89	29.77
27	9 16 49.5	ditto	8 56 30.00	+6.2	9 8 43.75	7 28 38.49	8 29.65	31.72	29.8[illegible]
Feb. 2	8 53 48	α Andromedæ	9 36 29.55	+3.84	9 8 51.14	7 28 17.09	8 51.05	36.62	30.1[illegible]
						Means	8 35.07	36.46	29.77

73° 13′ 39.4″, the latitude used in the computations throughout these observations. The details [illegible]
West Passage. The Corrections for Refraction were taken from [illegible]

behind a board, 1824 and 25. App. Alt. 7° 35′ 18″.43. By Lieut. Hen. Foster, (b) R.N.

Thermometer.	Winds (true)	WEATHER—REMARKS.
−5°		
−20	Eastly. fresh	Fine and clear
−21	,, light	Hazy
−21.8	North ,,	Hazy near the horizon, clear over head
−21	Eastly. ,,	Clear
−18.8	,, ,,	Sky clear, star twinkled much some time before sitting
−11	N.N.E. fresh	A few fleecy clouds, star clear, did not twinkle this evening
−19.5	N.E. light	Sky clear and fine
−18.5	Calm	Still clear evening
−24.5	N. moderate	Sky clear
−27.2	W.N.W.	Sky clear
−35	N.E. light	Sky clear
−28.2	North	Sky clear, star bright at setting, Aurora faint S.W.
−29	East	Fine and clear, Aurora faint in the S.W.
−31	N.E.	Sky clear, Aurora faint in the S.W.
−25.2	Calm	Clear, Aurora faint in the S.E. by S.
−27.8	E.N.E. mod.	Sky clear, Aurora faint in the S.S.W., star twinkled a little before setting
−12.6	East, fresh	
−16.5	,, light	Fine and clear, star quite bright at time of observation
−29.4	,, ,,	Clear to the westward, hazy in the eastern quarter
−31.5	,, ,,	Sky clear, with long streaming white clouds
−27.2	E.N.E. fresh	Sky hazy, a halo round the moon measuring 23° 29″
−36.5	Eastly. light	Clear over head and to the westward, thin slight haze to the eastward
−35.5	Calm	Still clear evening
−35.5	East, light	Sky clear
−38.3	,, ,,	Sky clear, Aurora faint to the S.S.W.
−38.5	,, ,,	Sky clear
−27.5	,, ,,	Sky clear, Aurora faint to the southward
−31.5	,, mod.	Sky clear
−28	,, ,,	Slight haze
−26.2	N.E. light	Sky clear
−25.5	N.N.E. fresh	Sky hazy, through which the star was indistinctly seen at setting
−37.2	,, light	Sky clear, except a few light clouds to the eastward, and low down southward
−42.2	N.E.	Sky clear
−27	N.W.bN. fr.	Sky clear, star bright and clear at setting
−40.9	E. moderate	Sky clear
−37	Calm	Sky clear
−27.3		

1824 and 25. Apparent Altitude 7° 37′ 08″.14, by Lieutenant Henry Foster, (b).

Thermometer.	Winds (true)	WEATHER—REMARKS.
−28.2°	North. light	Sky clear, star bright at setting, Aurora faint, S.W.
−29	East	Fine and clear, Aurora faint in the S.W.
−31	N.E.	Sky clear, Aurora faint S.W., star bright
−25.2	Calm	Clear, Aurora faint in the S.E.bS.
−27.8	E.N.E. mod.	Sky clear, Aurora faint in the S.S.W., the star twinkled a little before setting
−29.4	East, light	Clear to the westward, hazy in the eastern quarter
−31.5	,, ,,	Sky clear, with long streaming white clouds
−36.5	,, ,,	Clear over head, and to the westward, thin slight haze to the eastward
−35.5	,, ,,	Clear evening
−35.5	,, ,,	Sky clear
−38.3	,, ,,	Sky clear, Aurora faint to the S.S.W.
−38.5	,, ,,	Sky clear
−27.5	,, ,,	Sky clear, Aurora faint to the southward
−31.5	,, mod.	Sky clear
−28	,, ,,	Slight haze
−26.2	N.E. light	Sky clear
−25.5	N.N.E. fresh	Sky hazy, through which the star was indistinctly seen at setting
−37.2	,, light	Sky clear, except a few light clouds to the eastward, and low down southward
−42.2	N.E. ,,	Sky clear
−27	N.W.bN. fr.	Sky clear, star bright and clear at setting
−40.9	East, mod.	Sky clear
−32.0		

given in the Appendix to the Narrative of Captain Parry's third Voyage for the Discovery of a North
Young's Table, given at the end of the Nautical Almanac.

Observations for the Atmospheric Refraction observed by the Disappearance of α

Day	Time of α Aquilæ setting by No. 423	Transit observed: Star	Transit observed: Time by 423	Rate of 423	α Aquilæ: Hor. ∠ at setting	α Aquilæ: True Altitude	Observ-ed Re-fraction.	Tables in defect	At Temp. +48° Bar.
	h ′ ″		h ′ ″		h ′ ″	° ′ ″	′ ″	′ ″	Ins.
Dec. 8	3 31 58	α Arietis	2 55 46.28	+3.6	6 51 24.69	4 22 58.87	13 24.21	1 17.74	29.544
	Time by 649		Time by 649	649					
11	3 34 26	ditto	2 58 16.4	+4.9	6 51 32.55	4 23 07.45	13 15.63	1 11.58	29.708
13	3 26 59.50	ditto	2 50 34.03	+4.0	6 51 38.45	4 22 42.51	13 40.57	1 12.81	30.057
14	3 23 3	ditto	2 46 45.13	+6.4	6 51 30.77	4 23 14.99	13 8.09	0 47.12	30.190
16	3 15 24	Aldebaran	5 7 12.99	+5.7	6 51 34.38	4 22 59.17	13 23.91	0 40.48	30.099
20	2 59 58	α Arietis	2 23 38.26	+5.0	6 51 32.65	4 23 5.73	13 17.35	0 55.99	29.666
21	2 56 2.2	ditto	2 19 48.27	+6.2	6 51 26.79	4 23 32.61	12 50.47	0 25.65	29.79
22	2 52 15	ditto	2 15 56.88	+4.4	6 51 25 04	4 23 37.40	12 45.68	0 19.20	29.844
23	2 48 24.5	ditto	2 12 4.76	+4.2	6 51 26.66	4 23 30.87	12 52.60	0 19.74	29.81
25	2 40 32	ditto	2 4 20.26	0.0	6 51 24.71	4 23 38.55	12 44.73	0 18.22	29.92
26	2 36 43	ditto	2 00 29.36	+5.2	6 51 26.46	4 23 30.87	12 52.21	0 23.70	29.98
29	2 25 01	ditto	1 48 55.13	+4.1	6 51 18.67	4 24 3.14	12 19.94	0 13.83	29.666
Jan. 1	2 13 36.5	α Ceti	2 33 3.82	+5.2	6 51 25.34	4 23 33.73	12 49.35	0 24.82	29.836
2	2 9 48.4	α Arietis	1 33 32.33	+4 6	6 51 28.78	4 23 19.03	13 4.05	0 33.36	29.84
3	2 5 56.5	ditto	1 29 41 00	−2.9	6 51 28.28	4 23 21.04	13 2.04	0 26.92	29.82
5	1 58 12.8	ditto	1 21 56.76	+4.3	6 51 28.71	4 23 18.93	13 4.15	0 36.78	29.355
6	1 54 17.5	ditto	1 18 5.36	+4.55	6 51 24.81	4 23 35.10	12 47.98	0 25.22	29 32
10	1 39 2	ditto	1 2 42 78	+5.6	6 51 32.77	4 23 1.21	13 21.87	0 38.72	30.05
11	1 35 16	ditto	0 58 50.31	+4.0	6 51 38.27	4 22 38.03	13 45.05	0 54.68	30.12
12	1 31 21	ditto	0 54 59.36	+4.9	6 51 34.16	4 22 55.11	13 27.97	0 41.49	29.98
15	1 19 42.8	ditto	0 43 25.66	+4.5	6 51 28.60	4 23 18.14	13 4.94	0 36.70	29.73
16	1 15 53.8	ditto	0 39 36.36	+6.2	6 51 29.82	4 23 12.70	13 10.38	0 37.53	29.75
17	1 12 3.2	ditto	0 35 45.56	+5.07	6 51 30.03	4 23 11.67	13 11.41	0 50.69	29.62
18	1 8 6.8	ditto	0 31 53.48	+4.1	6 51 25.71	4 23 29.38	12 53.70	0 39.46	29.56
20	1 00 24.5	ditto	0 24 12.47	+5.4	6 51 27.34	4 23 22.51	13 00.57	0 40.48	29.37
25	12 41 22.5	ditto	0 05 00.32	+5.5	6 51 34.37	4 22 52.36	13 30.72	0 41.77	29.78
27	12 33 44.5	ditto	11 57 19.53	+6.2	6 51 37.12	4 22 40.56	13 42.52	1 15.03	29.83
Feb. 2	12 10 35	ditto	11 34 10.08	+3.84	6 51 36.92	4 22 40.58	13 42.50	0 46.65	30.22
4	12 2 36.5	α Arietis α Ceti	11 26 23.40 12 22 3.68	+2.91	6 51 24.91	4 23 30.61	12 52.47	0 32.87	30.05
7	11 50 59.5	α Arietis α Ceti	11 14 47.94 12 10 28.17	+4.1	6 51 23.22	4 23 37.31	12 45.77	0 25.88	29.59
8	11 47 21.8	α Andromedæ α Ceti	9 13 16.55 12 6 36.50	+4.33	6 51 37.05	4 22 39.29	12 43.79	1 4.91	29.74
9	11 43 25.2	α Arietis α Ceti	11 7 4.25 12 2 44.95	+4.41	6 51 32.11	4 22 59.85	13 23.23	0 38.91	29.95
						Means	13 09.37	0 40.28	29.80

Observations for the Atmospheric Refraction, observed by the disappearance of

Day	Time of α Aquilæ setting by No. 423	Transit observed: Star	Transit observed: Time by 423	Rate of 423	α Aquilæ: Hor. ∠ at setting	α Aquilæ: True Altitude	Observ-ed Re-fraction.	Tables in defect	At Temp. +48° Bar.
	h ′ ″		h ′ ″	″	h ′ ″	° ′ ″	′ ″	″	Ins.
Dec. 20	2 59 11	α Arietis	2 23 38.26	+5.0	6 50 45.52	4 26 23.13	13 8.37	52.67	29.66
21	2 55 15	ditto	2 19 48.27	+6.2	6 50 39.49	4 26 48.2	12 43.30	20.13	29 79
25	2 39 49.5	ditto	2 4 20.26	0.0	6 50 42.09	4 26 36.69	12 54.81	33.95	29.9
29	2 24 16	ditto	1 48 55.13	+4.1	6 50 33.51	4 27 12.28	12 19.52	19.06	29.66
Jan. 1	2 12 51.5	α Ceti	2 33 3.82	+5.2	6 50 40.22	4 26 42 82	12 48.68	29.80	29.8
2	2 09 00	α Arietis	1 33 32.33	+4.6	6 50 40.25	4 26 42.7	12 48.80	23.76	29.8
3	2 05 09	ditto	1 29 41.00	+2.9	6 50 40.65	4 26 40.55	12 50.95	21.48	29.8
5	1 57 26	ditto	1 21 56.76	+4.3	6 50 41.78	4 26 35.74	12 55.76	34 04	29.3
6	1 53 33.5	ditto	1 18 5.36	+4.55	6 50 40.69	4 26 39.91	12 51.59	34.48	29.3
10	1 38 19	ditto	1 2 42.78	+5.6	6 50 49 65	4 26 1.8	13 29.70	52.20	30.0
11	1 34 29.7	ditto	0 58 50.31	+4.0	6 50 51.84	4 25 52.11	13 39.39	54.67	30.1
12	1 30 35	ditto	0 54 59.36	+4.9	6 50 48.03	4 26 8.35	13 23.15	42.32	29.9
15	1 18 58.5	ditto	0 43 25.66	+4.5	6 50 44.18	4 26 23.96	13 7.54	44.95	29.7
16	1 15 7.5	ditto	0 39 36.36	+6.2	6 50 42.39	4 26 31.35	13 00.15	32.95	29.7
17	1 11 16.8	ditto	0 35 45.56	+5.07	6 50 43.50	4 26 30.25	13 01.25	46.19	29.6
20	0 59 39.5	ditto	0 24 12.47	+5.4	6 50 42.22	4 26 31.6	12 59.90	46.46	29.3
25	0 40 38.4	ditto	0 5 00.32	+5.5	6 50 50.15	4 25 57.55	13 33.95	50.66	29.7
27	0 32 54.2	ditto	11 57 19.53	+6 2	6 50 46.68	4 26 11.79	13 19.71	57.87	29.8
Feb. 2	12 9 47.8	ditto	11 34 10.08	+3.84	6 50 49.59	4 25 58.75	13 32 75	42.56	30.2
4	12 1 53.5	α Arietis α Ceti	11 26 23.40 12 22 3.68	+2.91	6 50 41.79	4 26 31.22	13 00.28	46.33	30.0
7	11 50 10 9	α Arietis α Ceti	11 14 47.94 12 10 28.17	+4.1	6 50 34.49	4 27 1.45	12 30.05	15.82	29.5
8	11 46 32.8	α Andromedæ α Ceti	9 13 16.55 12 6 36.50	+4.33	6 50 47.92	4 26 5.03	13 26.47	53.24	29 7
9	11 42 40.2	α Arietis α Ceti	11 7 04.25 12 2 44.96	+4.41	6 50 46.99	4 26 8.81	13 22.69	44.02	29.9
						Means	13 04.73	39.15	29.77

Aquilæ, 1824 and 25. Apparent Altitude 4° 36′ 23.″08. By Lieut. Hen. Foster, (b) R.N·

Thermometer.	Winds (true)	WEATHER—REMARKS.
−18°	N.N.E. squ.	Sky clear
−14	N.N.W. fr.	Clear and fine
−25	North, light	Clear and fine
−18.5	West „	Sky clear, star indistinctly seen at setting
−35	E.N.E. „	Sky clear, Aurora faint to the S.W., some streams N.W.
−26.3	North „	Clear still evening, Aurora faint to the S.W.
−26.8	„ fresh	Sky clear, Aurora bright to the S.W.
−27.2	S.W. light	Sky clear and fine, Aurora faint to the S.W.
−32	Calm	Fine clear evening, Aurora S.W.
−26	N.N.E. light	Sky clear, Aurora faint to the westward [faintly seen at setting
−26.5	E.N.E. mod.	Sky clear over head, thin light clouds near the horizon, through which the star was
−16	East, light	Fine and clear, thin haze near the horizon, through which stars were distinctly
−26	„ „	Sky clear, star bright at setting [seen
−30	„ „	Thin white clouds to the S.W., star set very bright
−33	„ mod.	Sky clear, star bright at setting
−35.5	„ light	Thin haze to the eastward, perfectly clear in other parts
−32.2	North „	Hazy, star distinctly seen
−35.5	East „	Clear
−39.3	„ „	Sky clear, Aurora faint to the S.S.W.
−38.7	„ „	Sky clear, stars very bright
−28	„ „	Clear and fine, Aurora faint to the southward, star somewhat obscured at setting
−32.8	„ mod.	Sky clear, stars bright, Aurora faint in the S.W. low down
−26.5	„ fresh	Somewhat hazy, Aurora faint low down to the W.S.W.
−23	N.E. strong	Sky clear, Aurora faint S.W., star somewhat indistinct at sitting, in consequence
−29	North, light	Sky clear, Aurora faint low down to the southward [of drift
−43.2	Easterly	Sky clear, a few thin clouds to the southward about the moon
−28	N.W. fresh	Sky clear, star bright at setting
−41.5	Eastly. light	Sky clear
−19.5	E.N.E. str.	and squally, sky clear over head, considerable drift, star bright at setting
−26.5	Calm	Clear and fine, faint twilight to the westward
−37	Calm	Clear still evening
−37.6	East, light	Sky perfectly clear
−29		

Aquilæ, 1824 and 25. Apparent Alt. 4° 39″ 31.″5. By Lieut. Henry Foster, (b)

−26.3°	Clear still	evening, Aurora faint to the S.W.
−26.8	North, fresh	Sky clear, Aurora bright to the S.W.
−26	N.N.E. light	Sky clear, Aurora faint to the westward
−16	East „	Fine and clear, thin haze near the horizon, through which stars were distinctly seen
−26	„ „	Sky clear, star bright at setting
−30	„ „	Thin white clouds to the S.W., star set very bright
−33	„ mod.	Sky clear, star bright at setting
−35.5	„ light	Thin haze to the eastward, perfectly clear in other parts
−32.2	North „	Hazy, but the star was distinctly seen
−35.5	Easterly „	Clear
−39.3	„ „	Sky clear, Aurora faint to the S.S.W.
−38.7	„ „	Sky clear, star bright
−28	„ „	Clear and fine, Aurora faint to the southward, star somewhat obscured at setting
−32.8	„ mod.	Sky clear, star bright, Aurora faint in the S.W. low down
−26.5	„ fresh	Somewhat hazy, Aurora faint low down to the W.S.W.
−29	North, light	Sky clear, Aurora faint low down to the southward
−43.2	East „	Sky clear, a few thin clouds to the southward about the moon
−28	N.W. fresh	Sky clear, star bright at setting
−41.5	East, light	Sky clear
−19.5	E.N.E.	Strong and squally, sky clear over head, considerable drift, star bright at setting
−26.5	Calm	Clear and fine, faint twilight to the westward
−37	Calm	Clear still evening
−37.6	Eastd. light	Sky perfectly clear
−31.1		

v. *Results of the Observations of* Mr. Fisher *and* Lieut. Foster, *compared with different Tables.*

Solar Refractions as computed by Mr. Fisher.

App. Alt.	Obs. Refr.	Therm.	Barom.	Dr. Young's Table in defect.
° ′ ″ 0 8 40	° ′ ″ 1 21 19	° −28	30.11	′ ″ 39 21
0 10 40	1 13 23	−28	30.11	32 0
0 28 22	0 54 22	−28	30.11	17 22
0 40 2	0 44 33	−28	30.11	10 6
0 50 2	0 39 47	−28	30.11	7 21
Sidereal Refraction.				
0 29 25	0 40 29	−28	30.00	3 54.2
0 43 14	0 36 24.8	−28	30.00	2 31.6

The same at higher altitudes.

Solar Refraction.

App. Alt.	Therm.	Bar.		
° ″ 10 54	° −27	29.79	Dr. Young's Table in defect	″ 12.7
11 26	−37	29.83	ditto	15.5
11 38	−19	29.46	ditto	9.9
12 0	−30	29.94	ditto	18.5
12 23	−35	29.98	ditto	10.2
13 18	−36	29.73	ditto	20.6
13 8	−35	29.70	ditto	10.0
14 3	−33	29.92	ditto	15.4
13.54	−37	30.10	ditto	12.5

Sidereal Refraction. (Rigel.)

App. Alt.	Therm.	Bar.			
° ″ 12 19	−14°	29.29	Dr. Young's Tables in	excess	″ 0.7
12 19	−23	29.50	,,	defect	0.2
12 19	−37	29.82	,,	excess	2.
12 19	−43	30.00	,,	,,	2.3

The observations of Mr. Fisher and of Mr. Foster fully justify the remark already made in the thirteenth number of these Collections, that the refractions at low temperatures, as indicated by Dr. Young's Table, which are found to be somewhat greater than those which Mr. Groombridge has observed in this country, would probably be found to be less in *excess* when applied to colder climates. That they would, however, have been actually so much in *defect* as these observations have demonstrated, could not have been foreseen without actual trial. The theory is indeed greatly illustrated by Mr. Fisher's very valuable experiment with the kite, which shows that the law of decrease of temperature must be supposed to be very different in the arctic regions from that which prevails in more moderate latitudes: but it serves fully to prove the impossibility of forming any hypothesis respecting the constitution of the atmosphere which shall be universally correct.

It will be proper to reduce the results of these observations to a table, such as was inserted in the thirteenth number of these Collections, showing the proportion of the effect of a single degree of Fahrenheit to the whole refraction. This proportion was assumed by Bradley as $\frac{1}{400}$ at 50°; Dr. Maskelyne and the French have made it $\frac{1}{500}$, and the mean result of Mr. Groombridge's observations gave $\frac{1}{430+2\,\text{alt.}^{\circ}}$. Mr. Fisher's observations below 4°, compared with the mean refraction of the Nautical Almanac, give $\frac{1}{289}$; Mr. Foster's, computed in the same manner, $\frac{1}{310}$; but when compared with each other only, no more than $\frac{1}{362}$, the discordance being chiefly in the two lower altitudes.

Star	Obs.	Mean app. alt.	Mean Fahr.	Mean Refr. Bar. 30	Table at 47°	Corr. Obs.	For − 1°Fahr. Obs. and T.	N. A.	Divisor.
		° ′ ″	°	′ ″	′ ″		″		
Sinus	7	0 29 25	−28	40 15	28 41		9.3	6.1	188
	7	0 30 55	−20	41 56	28 28		15.0	6.1	114
	7	0 43 14	−28	36 12	26 39		7.6	5.5	208
	7	0 45 33	−20	36 38	26 19		9.2	5.4	171
	7	0 50 53	−22	38 6	25 38		10.8	5.1	142
	7	0 58 22	−20	32 45	24 37		7.3	4.8	203
	7	0 58 49	−28	31 52	24 33		5.9	4.7	251
		2 35 31	−13	17 45	16 0		1.75	2.7	549
		2 54 56	−24	17 56	14 51		2.60	2.3	340
		3 7 34	−24	17 1	14 11		2.40	2.2	350
		3 16 35	−13	15 21	13 45		1.60	2.1	515
		3 19 16	−39	16 13	13 37		1.80	2.1	450
		3 20 46	−24	16 53	13 33		2.82	2.1	271
		3 21 9	−23	15 40	13 32		1.83	2.1	444
		3 41 1	−39	15 27	12 38		1.90	1.9	386
		3 49 44	−45	15 12	12 17		1.90	1.9	387
		4 0 19	−45	15 6	11 51		2.12	1.70	335
Rigel	17	12 18 28	−29¼	4 59	4 21.4		.48	.54	540
α Aquil.	32	4 36 23	−29	13 13.6	10 38	1.06	2.50	1.50	(600)254
α Aquil.	23	4 39 31	−31	13 11.2	10 33	2.05	2.03	1.48	(309)312
Arcturus	37	7 35 18	−27	8 39.7	6 55	1.45	1.41	0.90	(290)298
Arcturus	21	7 37 8	−32	8 38.7	6 49	1.65	1.40	0.90	(250)292

Altitude.	Fahr.	Refract. Bar. 30.	French Tables.	Bessel.	N. A.	Brinkley.	Ivory.
° ′ ″	°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0 8 40(☉)	−28	80 25	38 59	47 32	41 28	48 25	41 54
0 29 25	−28	40 15	34 17	39 1	36 18	40 8	36 40
0 43 14	−28	36 12	31 50	35 27	33 32	36 27	33 43
4 21 20	−41	13 51	13 42	13 46	13 26	13 59	13 46
4 39 31	−31	13 11	12 39	12 43	12 18	12 57	12 45
7 35 18	−27	8 40	8 20	8 16	8 2	8 20	8 14
12 18 28	−29¼	4 59	5 14	5 10	5 3	5 16	5 11

It follows from this comparison, that for altitudes less than 10°, and at very low temperatures, Dr. Brinkley's Tables are the nearest to the truth; there is only one instance in which the Tables of Bessel and of Ivory come nearer to the result of observation, being not quite so much short of it as Dr. Brinkley's exceed it. The mode of computation employed in the Tables of the Nautical Almanac

would require some little alteration if it were to be applied to extreme cases; the addition, for example, of a term multiplying the square of the difference of temperature by a coefficient varying from .05 at the horizon to .00 at 10° altitude. But in fact, the last correction, thus introduced, *can* only be empirical or conjectural. Dr. Brinkley's computation has the merit of great simplicity, and now that it is in great measure confirmed by experiment, must be allowed to be as successful as it is ingenious.

vi. Mr. Ivory's *mode of finding the length of the* Geodetic Curve.

Professor Bessel's investigation of the properties of the line of shortest distance on a spheroid was not brought forward as altogether original, but as including an abstract of what had before been done by himself and others. The Editor of these Collections does not think himself bound to decide on the chronology of every equation that is to be found in that paper: but he gladly profits by Mr. Ivory's obliging permission to extract such results from his last researches, as appear to be of the greatest practical utility. The term *simple,* as applied to his own solution of the problem, *was* certainly meant in comparison with that of Professor Bessel; and Mr. Ivory's later method may possibly be *more* simple in its application, though surely not in its principle.

For the difference of latitude (Phil. Mag. LXVII, No. 337, May 1826. P. 349.)

l being the latitude at the commencement of the line, and u at its termination (P. 340.)

μ the initial azimuth.

s the distance.

$$ms = z - \cos. z\,(p \sin. z + q \sin.^3 z).$$

$$\cos. i' = \frac{\cos. l \sin. \mu}{\sqrt{(1 + e^2 \cos.^2 l \cos.^2 \mu)}}. \quad \text{(P. 348.)}$$

$\sqrt{(1+e^2)}$ the equatorial semidiameter. (P. 345.)

$\sin. z = \dfrac{\sin. l}{\sin. i'}$; z being the arc of a great circle, of which i is the inclination to the equator of the inscribed sphere. (P. 341, 350.)

$$f^2 = \frac{e^2 \sin.^2 i'}{1 + ee}.$$

$$m = 1 - \frac{1}{4} f^2 - \frac{9}{64} f^4.$$

$$p = \frac{3}{4} f^2 + \frac{9}{64} f^4.$$

$$q = \frac{15}{32} f^4.$$

We have then, for Professor Bessel's example,

$l = 50^\circ\ 56'\ 6''.7.$

$\mu = 85^\circ\ 38'\ 56''.82.$

log. s or $\frac{\text{“}s\text{”}}{b}$ 8.964 9485.

log. $\frac{e^2}{1+e^2} = 7.8108710$, the square of the eccentricity,

log. $e^2 = 7.8136900.$

$i' = 51^\circ\ 4'\ 9''.94.$

$f^2 = 0.0039150.$

$f^4 = 0.0000153.$

log. $m = 5.3139988.$

log. $p = 2.78254.$

log. $q = 0.170$; all in seconds.

$\sin. z\ (^\circ) = \frac{\sin. l}{\sin. i'}$, or if i' and l are nearly equal,

$$\cot. z^\circ = \frac{\sqrt{(\sin.(i' + l) \sin.(i' - l)}}{\sin. l},$$

$z^\circ = 86^\circ\ 28'\ 19''.0.$

$ms^\circ = z^\circ - 37''.31.$

$ms^\circ = 86^\circ\ 27'\ 41''.69.$

log. m + log. s = log. $5^\circ\ 16'\ 48''.48.$

$m\,(s^\circ + s) = 91^\circ\ 44'\ 30''.17.$

$z^\circ + z = m\,(s^\circ + s) - 18''.4 = 91^\circ\ 44'\ 11''.77$

$\sin. u = \sin. i' \sin. (z^\circ + z)$; $u = 51^\circ\ 2'\ 12''.7.$

Again, for the difference of longitude φ,

$\sin. \varphi' = \frac{\cos. i' \ \sin. z}{\cos. l\ \cos. u}$, φ' being the difference of longitude of the extremities of the arc z.

$$\phi = \phi' - Cz - \frac{3e^4 \cos\ i' \sin.^2 i'}{16} \cos.\ (2z^\circ + z) \sin.\ z\,;$$

and in Bessel's example,

$e^2 \cos.\ i' = .0040917.$

$e^4 \cos.\ i' = .00002664.$

$e^6 \cos.\ i' = .00000017.$

$e^4 \cos.\ i' \sin.^2 i' = .00001612$; whence

$C = .0020389$, and the logarithms of the coefficient of the remaining term reduced to seconds is 9.791. But $z = 18952''.77$, and $\phi = \phi' - 38''.64 - 0''.06 = 8^\circ\ 21'\ 19''.06$. The result is as accurate as the tables of logarithms employed will admit: how far the process is more *simple* than the method which has occurred to the Editor, not of this "*Journal*," but of these *Collections*, he is inclined to leave undetermined for the future decision of practical computers.

7 *June*, 1826.

Art. XVIII. ANALYSIS OF SCIENTIFIC BOOKS.

1. *Papers on various Subjects connected with the Survey of the Coast of the United States.* *By* F. R. Hassler.

[Extracted from the *American Philosophical Transactions,* vol. ii. New Series. Philadelphia, 1824, pp. 200. Not published until December, 1825.]

The accurate solution of those astronomical and geographical problems, by which the position of places upon the earth's surface may be ascertained in such a manner as to furnish data for correct maps, is attended with no small difficulty. It is impossible to combine together partial surveys of small districts, to form one harmonious and consistent whole; the methods of ordinary surveying are therefore insufficient. On the other hand, astronomical observation alone is not to be depended upon, in as much as there are limits beyond which the accurate determination of longitude and latitude becomes impracticable. It is therefore necessary to have recourse to mixed methods, in which lines and angles measured on the earth's surface are combined with the best means furnished by astronomy. The consideration of these mixed methods constitutes a particular branch of science, to which the French have given the name of *Géodésie*, a word that has not yet been naturalized in the English language.

The origin of this branch of science is to be traced in efforts made by the astronomers of the Alexandrian school to determine the magnitude of the earth; and it has received great improvements recently, in the course of the investigation of the true figure of the earth, and of the inquiry into its magnitude, with the view of taking a quadrant of the meridian as a standard of measure. The great accuracy required in performing the surveys and observations that relate to the last-named object, has caused an improvement in the construction of instruments, and in the methods of calculation, beyond what would probably have been introduced, had geographical questions been alone considered, but which are found to be the only safe and proper methods that can be employed in their solution.

The general principle of geodetic surveying consists in the measurement of the several angles of a net-work of triangles, spread over the surface of the country to be examined, and the determination of the magnitudes of their sides in reference to one or more bases accurately measured, and forming each a side of one of the triangles. The position of these triangles is then to be determined in relation to the meridians and parallels of latitude of the terrestrial spheroid.

It might at first sight appear that such a process was one of no great complexity, and within the reach of persons of small acquirements; but this is a most mistaken opinion. Every error of measurement or observation, every fault of calculation, and every omission of circumstances, are multiplied and increased as the survey is extended, until they will finally amount to discrepancies of the grossest kind. No pains then ought to be spared in obtaining the best instruments, in employing the most skilful observers, and in calculating the results, if it be desired, to reach such a degree of accuracy as shall compare with the great trigonometric surveys of France and England, or shall be consistent with the safe use of the maps and charts, constructed upon the basis of the observations. This view of the subject appears to have deeply impressed the American government. Instruments of great value and beauty, the work of the most distinguished artists, were procured at great cost; Mr. Hassler, who to great scientific attainments adds much skill and practice as an observer, was engaged to superintend their construction, and conduct the survey; and the part that was actually performed, was conducted in such a manner, as to shew that the whole, when completed, would have exceeded in accuracy any other similar work. To say this is no small praise, when we consider the talent and zeal that are apparent in the several works published by the French Institute and the British Royal Society, in relation to the operations performed in the two several countries. We regret that we should be compelled to state, that the survey of the coast of the United States, begun under such auspices, has not been permitted to proceed; the spirit of intelligence and knowledge that actuated Mr. Jefferson in proposing the plan, and illustrated the several administrations of Messrs. Gallatin and Dallas in the treasury department of that country, does not seem to have inspired their successors. Partial surveys of coasts and harbours are indeed occasionally made, but the idea of combining them into one complete delineation of the geography and topography of the coast of the United States appears to have been abandoned. This is not honourable to that intelligent people: the charge made by a British periodical work, of their deficiency in geographical science, is not entirely unfounded, if we can judge solely from their published maps, and it is time that they did something to remove the stigma. The work before us is evidence that there does exist the requisite knowledge; it is therefore the duty of the government to see that it no longer remain unemployed.

In a great trigonometrical survey, the first and necessary preliminary step consists in an examination of the country, for the purpose of selecting the stations at which signals are to be erected, to form the angular points of the principal triangles.

These must be so elevated as to furnish an open view in the directions necessary for the extension of the survey, and chosen in such a manner as to permit the triangles to have a form that will afford the greatest chance of accurate calculation. The best condition of a triangle is, that it should be equilateral; but as an entire series of such triangles is evidently impossible in practice, all that can be done is to endeavour that they shall deviate as little as possible from that form, admitting no angle that much exceeds a right angle, nor any less than thirty degrees. The best instrument to employ in such a *reconnoissance* is a good refracting telescope, of not less than thirty inches focal length; and the common equatorial stand of such an instrument, used with its axis in a vertical, instead of the usual polar position, will give a sufficient approximation to the size of the angles. The stations being chosen, signals must next be erected at each of them. In the earlier surveys, artificial objects, such as steeples and towns, or natural objects, such as trees, were employed; but to signals of this nature there are insuperable objections. Signals expressly constructed for the purpose have, in consequence, superseded their use. Delambre and Mechain made use, in the earlier part of the French survey, of Argand lamps with parabolic reflectors, whose axes were directed towards the observer; these were found however to be attended with many difficulties: they can be used at night only, which is in all cases laborious, in some, dangerous. Great care and attention are demanded in directing the axis of the mirrors, and in keeping up the lights; while, with every precaution, the mists and dews of the night cause such a refraction, that they appear to oscillate around their true place. For night signals, in the British survey, Bengal lights were used; these are more brilliant and conspicuous than lamps, having been distinctly seen and observed across the British channel, at a distance of forty miles, and require no other care than that of lighting them at the appointed time: they have, however, all the other faults of lamp signals, and, besides, do not burn for a sufficient length of time to permit the use of the repeating circle, or even of the theodolite, if applied to compensate its own errors. The signals of Picard were large fires, but these have long been abandoned.

Of artificial signals visible by day there have been employed,—by Delambre, truncated pyramids of wood, formed of four posts meeting, and covered at top with a plank, the open space beneath serving for the place of observation; in the English survey simple masts were used, and these are well fitted for the service of the great theodolite, and answer admirably, when projected against the sky, but when they have a background of dark objects, they become obscure, even if painted white. In the surveys conducted by Tralles, in Switzerland, spheres of a white substance were used: they may be constructed simply by cover-

ing three hoops with canvass, and raising them on a mast; and the form possesses peculiar advantages when the angles are measured by the repeating circle, which is employed in planes that are almost always inclined to the horizon. In the work before us a new form of signal is described that is preferable to any of those above mentioned; it consists of a vessel of planished tin plate; the lower part has the form of a truncated cone open at bottom, whose height is nineteeen inches, the lower diameter seventeen, and the upper fourteen. The vessel is closed at top by a plate three inches in diameter, and elevated five inches above the upper diameter of the truncated cone; the intervening space is enclosed by a tin plate, which has, in consequence, also the form of a truncated cone of a greater vertical angle than that beneath. Under favourable circumstances of light and distance, these signals appeared "like a strong luminous disk, often requiring the use of a dark glass before the eye." Even in distances of from thirty to forty miles, they presented a distinct illuminated point, when the sun was in such a position as to have its rays reflected directly to the observer; and the continuance of this reflection is sufficiently long to admit of every necessary observation. As the point of reflection is not always in the direction of the centre of the signal, a reduction was used, to correct the observed angle for the error arising from this cause. To perpetuate the recollection of the position of the signals, large truncated conical vessels of earthenware were buried, with their axes exactly corresponding with the axes of the signals. As earthenware is almost indestructible, it is probable that no monument equally durable can be obtained at so small an expense.

The extremity of the line chosen for a base must be marked by two similar signals, and it will form a side of one of the triangles. To measure the base great care and precaution is necessary. The measures employed must be accurately determined in relation to some natural or artificial standards; their variation in length, in consequence of alternations of temperature, well known; their direction carefully maintained in the vertical plane passing through the signals. In the later French surveys rods of metal are used; in the English, at first, rods of metal, then cylinders of glass, and finally, steel chains, resting in troughs, and stretched by a constant weight. In all these several modes, it was attempted to join the bars or chains to the point reached by the previous measure, or a vertical line passing through it, by mechanical contact. In the American survey under consideration, an optical contact was preferred. For this purpose compound microscopes were employed, whose object-glasses were formed of two half-lenses of unequal focal lengths, by which arrangement a cobweb stretched across a semicircular opening at the end of the bar, and the image of the intersection of two lines drawn on a

plate of ivory attached to the microscope, may be seen with equal distinctness at the same instant. The contact is ascertained by making the cobweb appear to bisect this angle. The microscope remaining undisturbed, the bar is removed, and the cobweb stretched over the opening in the extremity of the succeeding bar is made to bisect the same angle. This method of ascertaining the contact of the bars employed in measuring a base, appears to us to be very superior to any that is merely mechanical. The apparatus used in measuring bases, whatever may be the material employed, is subject to expansion and contraction, with alternations of temperature. The effect of this may be determined by means of the admitted rate of expansion of the substance used, but it is always better to ascertain it directly in reference to the apparatus itself. In a preceding volume of the *Transactions of the American Philosophical Society* is to be found a detailed account of the manner in which this was done in the present case, which we recommend to the perusal of our readers as extremely ingenious. It is never practicable to measure a base at the level of the sea, and rarely in a level line; for this reason the inclination of each set of bars must be ascertained and reduced to a level by calculation. The lines, thus measured and reduced, form sides of a polygon, circumscribing a curve, parallel to a line on the surface of the terrestrial spheroid; their sum, however, differs so little from the length of the curve itself, as to require no correction. The last step in this process is to reduce the length of this curve to that of its parallel drawn on the surface of the earth, or in other words to the level of the sea.

The next subject to which we shall refer is the measure of the angles. The earliest trigonometrical survey on record is that performed by Snellius in Holland. At this period telescopic sights had not come into general use, and hence his angles were liable to a considerable degree of uncertainty. Picard employed in the measure of his terrestrial angles a large portable quadrant with two telescopic sights; the one fixed at zero on the limb, the other moveable: the plane of the instrument being made to coincide with that passing through the objects, the fixed telescope was directed to the one, and the moveable to the other; in this manner the arc of the oblique circle comprised between their directions was measured. To reduce this angle to that at the zenith, or to the horizontal arc intercepted between the verticals of the two objects, a correction is necessary, arising from the resolution of a spherical triangle, the data of which, in addition to the observed arc, are the zenith distances of the two objects. Mechain and Delambre, in the survey which forms the basis of the French metrical system, employed the repeating circle, an instrument which Borda had just invented, applying a principle originally proposed by Mayer. This instrument possesses several important

advantages: several verniers may be used in reading the angles, by which accidental errors in division will be lessened in all cases, and become null when the whole circumference has been passed over. The peculiar property of a circle, by which the sum of two opposite vertical arcs is always equal to twice the angle at the centre, destroys the error that may arise from a want of concentricity, in the graduated arc, and the axis on which the verniers revolve; and the observed angle may be frequently multiplied, thus giving a nicety in the results of each vernier, equivalent to that fraction of the smallest division, whose numerator is unity, and whose denominator is the number of times the angle is repeated. The circle is also capable of being used in observations of zenith distances, and azimuths. It may therefore supply the place of every other instrument for measuring angles, and was the only one used in the French survey, being sufficient for every purpose, whether geodetic, or purely astronomical. But in determining horizontal angles and azimuths, it requires several calculated corrections, for one of the telescopes is eccentric, and the angles are measured, as in the case of the quadrant, in the plane of the objects.

In a survey of the Highlands of Scotland, General Roy had employed a large theodolite, made by Ramsden. In this instrument the artist had attained an accuracy of construction, and a minuteness of division, before unexampled. In the subsequent operations of the same nature in England, a similar instrument was employed; and it was believed that the mechanical accuracy of the construction was such, as to obviate the necessity of recurring to the principle of repetition, either as a means of obtaining less portions of the circle, or of correcting errors arising from inequalities in the magnitude of the divisions. The theodolite possesses a great advantage over the repeating circle, in always giving the horizontal arc intercepted between the vertical circles, passing through the signals, and the axis of the motion of the telescope passes through the centre of the graduated circle. As this arc is the same with the measure of the angle of the spherical or spheroidal triangle, it requires no reduction, and much labour of calculation is therefore saved, as well as the observation of the zenith distances of the signals. It is also applicable, as we shall explain hereafter, with much more ease than the repeating circle, to observations of azimuth; but it is not capable of measuring zenith distances, and is, therefore, not in any way adapted for the determination of time or of latitude.

Mr. Hassler, who, when acting as the coadjutor of Mr. Tralles in the trigonometrical survey of Switzerland, had an opportunity of comparing the theodolite with the repeating circle, made choice of the former in preference, for determining the angles of his triangles, and his azimuths. He therefore obtained a very beau-

tiful one, of two feet in diameter, which was constructed, under his personal superintendence, by Troughton. In this instrument a number of improvements were introduced, upon the original form of Ramsden, and it is without doubt the most perfect of its kind that has ever been made.

The principal of these improvements consisted in giving it the property of repetition, and making the pillars that support the telescope of such a height, as to permit it to describe an entire vertical circle. This last part of the improvement was found upon trial to be of extreme importance ; but it was not found necessary to employ the repeating property, superior advantages being obtained by the mode of observation we are about to describe.

In spite of the great care and attention betowed upon this instrument by the celebrated maker, it was found on trial to be affected by certain small errors, probably inseparable from the very nature of the materials, and for which no remedy is to be found, either in the skill of the artist, or the perfection of his tools. The discovery of these errors, that, although small, are not to be neglected in investigations requiring such extreme accuracy, led to an inquiry into their causes, and to the discovery of the appropriate remedies; as these are applicable to all instruments, whether small or large, that are constructed on similar principles, and are besides novel, we shall detail them.

In the first place the instrument may not, indeed, mathematically speaking, cannot, be accurately centred. The property of the circle that has already been mentioned, furnishes a correction for this in the use of two opposite verniers, and so also is there a correction in the use of any even number of readings. We are indebted to Mr. Hassler for the first strict demonstration of the fact, that three or any other unequal number of verniers, arranged at equal distances on the circumference, will produce a result as favourable. Other advantages, of a triple reading, are too well known to require explanation.

In the second place, the axis of motion may not be perpendicular to the divided plate of the instrument. This error, Mr. Hassler has shewn, may be completely compensated, by making the legs of the instrument (three in number) change their places, so that each angle shall be measured in three different positions of the instruments: the mean of all the arcs thus obtained is the true angle in the horizontal plane.

Lastly, errors may arise from the axis of the telescope not being parallel to the horizontal line determined by the level. These may be compensated by reversing the telescope, and making a second observation in an inverted position, in relation to the graduated arc.

Directions for applying these principles to practice are given in the work before us, at full length. By following them, the ob-

server will be almost independent of inaccuracies in the construction of his instruments, even more considerable than can well occur at the present day.

When instruments of such power as the great theodolite, or the repeating circle, are used, the difference that exists between the three angles of a plane triangle, and the three angles observed at for reduced to the spheroidal surface of the earth, becomes sensible, even when the sides are not more than ten miles in length. Two modes present themselves of allowing for this excess in the calculation: the first consists in using the angles of the chords, and the chords themselves, as the angles and sides of a plane triangle; the second is founded on a beautiful theorem of Lagrange, who has demonstrated, that if one-third of the spherical excess be deducted from each angle, the opposite sides become proportioned to the sides of the corrected angles; their magnitude may therefore be calculated by the rules of plane trigonometry.

In the determination of latitude, Picard made use of the zenith sector, which observes stars of known declination, that culminate near the zenith, the difference between whose meridian altitude and declination is the complement of the latitude. His results are however incorrect, in consequence of his ignorance of the nutation of the earth's axis, and the aberration of the fixed stars. An instrument of the same nature, but of very superior quality, by Ramsden, was used at a sufficient number of the stations of the British survey. Delambre and Mechain employed the repeating circle for the determination of this element; it is much better for this purpose than the zenith sector, as it affords an opportunity for many more observations within a given time; it is not confined to stars culminating near the zenith, but is applicable to the sun, to any star whose position is known, and even to those whose declination is unknown, if they be twice visible on the meridian within twenty-four hours. The pole-star furnished the principal subject of observation for latitudes in the French survey, and its altitudes near the meridian were tested by altitudes at the greatest elongation. The sun was also occasionally used, and, it is probable, might have been employed oftener to advantage, as well as stars having a southern declination, in order to compensate a possible error that may arise in repeating instruments, which is pointed out by Troughton, in the first number of the *Transactions of the Astronomical Society in London*, and can only be compensated by observations made on two opposite sides of the zenith.

For the American survey, a repeating circle of two feet in diameter was provided, to determine the latitudes. It had an improvement that we have not seen described in any other, and which was suggested to the artist by Mr. Hassler; this consists in applying verniers, attached to, and carried by the back telescope, by means of which an entire series of angles may be ob-

tained, in case the intervention of clouds or other accidents should render it impossible to finish the series with the front telescope, whose indications would be, in that event, entirely lost.

The directions of the sides and angles of the triangles of a trigonometrical survey, are found by observing the azimuths of the heavenly bodies. Delambre made use principally of the sun when rising, or about to set, and occasionally of the pole-star, placing the repeating circle in a plane passing through the signal and the heavenly body; but as this plane is variable with the change of altitude in the heavenly body, such observations are difficult and laborious. For this reason they were made more seldom in the course of the French survey than could be wished. They also require a reduction to the horizon, and a correction for the eccentricity of the lower telescope. The theodolite is much better fitted for the observation of azimuths, and we have in Mr. Hassler's papers two easy and novel methods, requiring so little labour in the observer, that they may be performed without inconvenience at every station.

Were the earth a perfect sphere, the azimuth of a single side of any one of the triangles would enable us to calculate the direction of all the others; from these the lengths of the perpendicular to the meridian, and the differences of longitude among the stations could be determined. But as the earth is not a perfect sphere, this method is not to be depended upon. Upon the hypothesis of the earth's being a spheroid of revolution, the difference between the true and calculated azimuth is so small, that Delambre states it may be entirely neglected in triangles not far distant from each other. But in distant triangles this difference will at last become of importance, and thus several observations of azimuth at different stations are indispensable; while the probability that the earth is not a regular figure, would impress upon us the propriety of determining the azimuth at one station in every triangle. If, in the French survey, the observations of azimuth were not sufficiently frequent, a still greater cause of complaint exists in relation to the English observers. Their instrument furnished them with much more ready means of observation, and yet we know of no other determination of the direction of any side of their triangles, except one made by placing the theodolite immediately over the transit of the observatory at Greenwich, and measuring the angle between the meridian mark and one of their stations. The perpendiculars to the meridian, and difference of longitude, were determined by the calculation of spheroidal triangles, an essential element of which is the ellipticity of the earth, as deduced from their own measure of the meridian. As this oblateness is from some local cause much greater than the truth, there is a constant error that affects all their longitudes, amounting to $\frac{1}{300}$ part of the angle at the pole. This, in extreme, cases

amounts to 4″ of time, or $\frac{1}{17}$ of a degree, as has been conclusively shewn by Dr. Tiarks, and very much diminishes the value of the beautiful maps published by the Board of Ordnance. Indeed the British government would render an essential service to science, by directing the repetition of a great portion of that survey, particularly as an error is to be apprehended in the base itself, the bar of General Roy being found, on examination by Kuter, not to bear the relation that he has stated to other standards, thus casting suspicion upon his other measures.

Even the determination of azimuths as frequently as has been recommended, should not be relied upon solely for giving differences of longitudes, especially when the country has a considerable breadth in the direction of the parallel. General Lambton in his Indian survey was well aware of this, and attempted the determination of longitude, by means of a fire-signal that was visible from two places on the same parallel, distant from each other one hundred and thirty-five miles. Few instances occur when such a method is practicable to so great advantage. Other modes should therefore be resorted to. The comparison of lunar transits, carefully and frequently observed at fixed observations, is probably the best; but as a substitute for these, the passage of the moon over the meridian, observed in relation to neighbouring stars, as originally practised by Nicolai, and improved by Mr. Francis Baily, may be resorted to, with almost equal advantage. By the first of these observations, an accuracy in the determination of longitude to about $\frac{2}{5}$ths of a second of time, or 6″ of a degree, may be readily obtained. In a country of any great extent in the direction of the parallel, two fixed observations should be established, as remote in longitude from each other as circumstances will permit, the observations at which will serve as a check upon, and furnish corrections to, the several results of the actual survey. The erection of two such establishments at the two extremes of the coast of the United States, say in the States of Maine and Georgia, was contemplated in the original plan, and the necessary instruments were obtained. Circumstances, however, led to the abandonment of this essential part of the project, and to the substitution of a proposal for a single observatory at the seat of government. Even this has not been carried into effect, and remained unheeded, until the present chief magistrate, in his first message to Congress, recalled the attention of that body to this important object. It is indeed to be regretted, that in America, as well as in older countries, the pursuit of scientific objects should be frequently forgotten by legislative bodies, in the pressure of ordinary business, and the contests of party; but it is still more unfortunate, when the jealousy of persons incompetent to perform, or even to judge of the value of such investigations, should be permitted to interrupt their performance, or deprive the agents of the hard-earned reward of their exertions. It has been

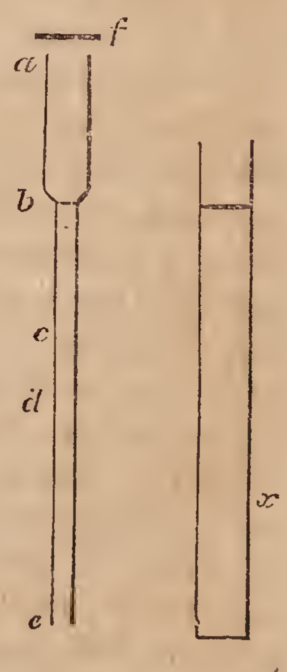
hinted that the suspension of the survey of the coast of the United States is as much owing to the efforts of persons bearing commissions in the naval and military service, who were jealous of the employment of a civilian, as to the ignorance of the then administration, not only of the importance and value of the object, but of the proper manner of carrying it into effect. We might take occasion to remark upon this, were it not that similar instances of jealousy and imperfect information are to be found in the history of other countries.

The survey being suspended shortly after its commencement, the work before us furnishes no examples of the formation of the secondary triangles, or of the details of Topography and Hydrography, that would have been incident to it in its complete state. It would therefore be irrelevant to treat of the principles and manner of performing these portions of the work. We shall in consequence conclude our review with the single remark, that Mr. Hassler has been as unfortunate, in the delay of the publication of his papers by the American Philosophical Society, as in the suspension of his work by the government. Had they appeared at an earlier date, we feel satisfied that they would have produced such an effect upon public sentiment, as would have imperatively called for the continuation of the survey. In the mean-time, six years of the active part of his life have been permitted to elapse, and the opportunity of forming successors and assistants under his tuition has been allowed to pass by.

Art. XIX.—MISCELLANEOUS INTELLIGENCE.

I. Mechanical Science.

1. *Leslie's Apparatus for ascertaining the Specific Gravity of Powders.*—The instrument consists of a glass tube *a c*, about three feet long, and open at both ends. The wide part *a b* is about 4-10ths of an inch in diameter; the part *b c* about 2-10ths. The two parts communicate at *b*, by an extremely fine slit, which suffers air to pass, but retains sand or powder. The mouth at *a* is ground smooth, and can be shut, so as to be air-tight, by a small glass plate *f*. The substance whose specific gravity we wish to find, suppose it to be sand, is put into the wide part of the tube *a b*, which may either be filled to the top or not. The tube being then held in a vertical position, has the narrow part immersed into mercury, contained in an open vessel *x*, till the metal rises within to the gorge *b*. The lid is then fitted on air-tight



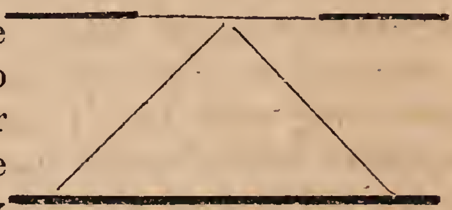
at *a*. In this state, it is evident there is no air in the tube, except that mixed with the sand in the cavity *a b*. Suppose the barometer at the time to stand at 30 inches, and that the tube is lifted perpendicularly upwards till the mercury stands in the inside of *b c*, at a point *c*, 15 inches (or one-half 30) above its surface, in the open vessel; it is evident then that the air in the inside of the tube is subjected to a pressure of exactly half an atmosphere, and of course it dilates and fills precisely twice the space it originally occupied. It follows, too, that since the air is dilated to twice its bulk, the cavity *a b* contains just half of what it did at first, and the cavity *b c*, now containing the other half, the quantity of air in each of these parts of the tube is equal. In other words, the quantity of air in *b c* is exactly equal to what is mixed with the sand in *a b*, and occupies precisely the same space which the *whole* occupied *before* its dilatation. Let us now suppose the sand to be taken out, and the same experiment repeated, but with this difference, that the cavity *a b* is filled with air only. It is obvious that the quantity being greater, it will, when dilated, to double the bulk, under a pressure of 15 inches, occupy a larger space, and the mercury will rise, let us suppose, only to *d*. But the attenuated air in the narrow tube always occupies exactly the space which the whole occupied at ordinary atmospheric pressure, and this space therefore is in the one case the cavity *b c*, and in the other *b d*. Hence it follows that the cavity *c d*, which is the difference between these, is equal to the *bulk of the solid matter in the sand*. Now, by marking the number of grains of water held by the narrow tube *b c* on a graduated scale attached to it, we can find at once what is the weight of a quantity of water equal in bulk to the solid matter in the sand, and by comparing this with the weight of the sand we have its true specific gravity.

Aware that some solid bodies, such as charcoal, hold much condensed air in their pores, and that probably they retain part of this even when reduced to powder, Professor Leslie obviates the chances of error arising from this source, by comparing the dilatation which takes place under different degrees of pressure, under 10 inches and 20 for instance, or $7\frac{1}{2}$ and 15.

Charcoal, from its porosity, is so light, that its specific gravity as assigned in books, is generally under 0.5, less than half the weight of water, or $\frac{1}{7}$ the weight of diamond; taken in powder by the above instrument it exceeds that of diamond, is one-half greater than that of whinstone, and is, of course, more than seven times heavier than has usually been supposed. Mahogany is generally estimated at 1.36, but mahogany saw-dust proves by the instrument to be 1.68: wheat-flour is 1.56; pounded sugar, 1.83; and common salt, 2.15: the last agrees very accurately with the common estimate. Writing-paper, rolled hard by the hand, had a specific gravity of 1.78, the solid matter present

being less than one-third of the space it apparently filled. One of the most remarkable results was with an apparently very light specimen of volcanic ashes, which was found to have a specific gravity of 4.4. These results are, however, given as approximations merely by the first instrument constructed.—*Scotsman.*

2. *New Photometer, by* Mr. Ritchie.—Mr. Ritchie, of Nain, has constructed a very simple photometer, on the principle of Bouguer. It consists of a rectangular box, about an inch and a half, or two inches square, open at both ends, and blackened within, for the purpose of absorbing irregular light. Two rectangular pieces of plane mirror are placed within the box, at right angles with each other, and at an angle of 45° with the sides of the box. A rectangular opening is cut in the upper side, or lid of the box, about an inch long and an eighth broad, and passing over the line formed by the intersection of the two mirrors, is half over the one and half over the other: the aperture is to be covered with a slip of fine tissue, or oiled paper.



When used, it is to be placed in the same straight line between the two flames to be compared, they being distant six or eight feet from each other, and is to be moved until the disc of paper is equally illuminated by the two flames. The illuminating powers of the flames will then be directly as the squares of their distances from the middle of the photometer. In viewing the illuminated disc, it is well to look at it through a prismatic box, about eight inches long, blackened within, to absorb strong light.

Sometimes, instead of using mirrors and the paper screen, the inclined planes are covered with white paper, and looked at directly through the aperture. However the instrument is used, a mean of several observations should be taken, the instrument being turned round each time.

When the lights are of different colours, the plan Mr. Ritchie recommends is, to cover the rectangular opening in the instrument with a piece of fine white paper, printed distinctly with a small type; the paper is to be brushed over with oil, and then the instrument being placed between the lights, they are to be moved till the printing can be read continuously along the paper, with equal ease on the one side as the other. In the second form, the printed paper is to be pasted on the mirrors, or the inclined surfaces, against which they lie, and is then to be read through the opening. It is advantageous to enlarge the opening in these applications of printed paper.

3. *Construction of a Pendulum, which corrects the Inequality arising from Variation in the Density of the Atmosphere.* By Fran-

cesco Carlini.—It is known that the resistance of the air does not perceptibly alter the time of oscillation of a pendulum, but influences it only in consequence of diminishing; by its density, the gravity of the weight applied to the pendulum, so that its influence is greater or less according as the specific gravity of the weight itself is smaller or greater. For this reason the weights of pendulums are generally made of lead, and they would be better still if made of gold or platinum, were not these metals too rare and costly. If the density of the air were constant, no other inconvenience would be felt than a smaller capability in the bob of resisting the impulsion of the moving force, which is not always perfectly regular; but as this density is continually varying, as is demonstrated by barometrical observation, an inequality is originated on the motion of our time-pieces, different from, and independent of, that caused by the dilatation of the metal. This consideration is so evident and simple, that it is surprising it should have escaped the attention of those engaged in perfecting clocks; and yet I find no author who has made mention of it. The first who gave me occasion to reflect on this source of irregularity was M. Biot, during the short time that he was with us, engaged in his experiments on the length of the pendulum. Discoursing with him, I made a calculation of the maximum of inequality which might be produced by this cause. The following are the elements of this calculation:—The specific gravity of lead, of which most of the bobs of pendulums are made, is 11.35, water being unity, the maximum density of air with us, the barometer being at 28 inches 7 lines, and thermometer at $-10°$ R. ($9\frac{1}{2}°$ F.) is 0.001228, and its minimum density, supposing the barometer at 26.7, and the thermometer at 27° R., ($92\frac{3}{4}°$ F.), is 0.000959. In the first case the bob would lose in the air $\frac{0.001228}{11.35}$ $=0.0001082$ of its gravity, and in the second case only $\frac{0.000959}{11.35}$ $=0.0000845$. The difference of gravity in the two states being 0.0000237.

The number of oscillations made by a pendulum in 24^h is in the inverse ratio of the roots of the motive forces, so that the number of oscillations of a pendulum's beating seconds in vacuo being 86400 in 24^h, the number of oscillations in the air would be $=\frac{86400}{\sqrt{1+\frac{\delta}{D}}} = 86400\left(1-\frac{1}{2}\frac{\delta}{D}\right)$ calling D the density of the bob, and δ that of the air.

From this formula it may be deduced, that a pendulum clock in our climate may differ a whole second in twenty-four hours,

by the mere variation of the density of the atmosphere. This was also very nearly the result obtained, when calculating in round numbers with M. Biot.

Reflecting upon this subject, the idea suggested itself of searching for a mechanical mode, by which a compensation for this irregularity might be obtained, as is done for the effects of heat. It is quite certain, that if the pendulum is composed of homogeneous matter, or if of matter of various densities, the whole of which is collected beneath the centre of suspension, then an augmentation in the density of the air must cause a retardation of the clock. Hence, in this way, there is no possibility of compensation; but the case is a very different one, if we suppose that a body of smaller density than the bob, but making part of the pendulum, is placed above the centre of suspension.

Suppose a pendulum ABC, of which B is the centre of suspension, A a sphere of cork of the volume v, and C a bob of lead, of the volume V, let the specific gravity of the cork $= d$, that of the lead $= \mathrm{D}$, and call the variable density of the atmosphere δ, we shall have the motive force of the body A $= \frac{d-\delta}{d}$, that of the body C $= \frac{\mathrm{D}-\delta}{\mathrm{D}}$; the mass of the body A $= v\,d$, that of the body C $= \mathrm{VD}$.

Now, let L $=$ the length of the simple pendulum oscillating in vacuo, and isochronous with our compound pendulum oscillating in the air. Let AB $= x$, BC $= y$, and, for simplification, neglect the extension of the bodies A and C, and the mass of the rod which connects them $\mathrm{L} = \frac{y^2\,\mathrm{VD} + x^2\,v\,d}{y\,(\mathrm{D}-\delta)\,\mathrm{V} - x\,(d-\delta)\,v}$.

Now that the length L may be constant, whatever is the value of δ, it is necessary that the terms multiplied by this quantity should equal each other. This is effected by making $y\,\mathrm{V} = x\,v$, which will be supposing the two bodies are placed at such distances from the centre of suspension as are in the inverse ratio of their volume.

From this solution it would appear that it is not necessary that the specific gravities should differ from each other, since the equation $y\,\mathrm{V} = x\,v$ is independent of them; but it is to be observed that, if the specific gravities are equal, we shall have the denominator of the value of $\mathrm{L} = o$; that is to say, a pendulum will be obtained, the time of whose vibrations will be infinite. It is requisite, therefore, that the two specific gravities should differ much from each other, and then the force which animates the

system will be the greatest possible. For this reason I have, in the example, taken lead and cork, and for the latter may be substituted a thin, close, copper globe.

The above ratio between the specific gravities and the distances from the point of suspension being retained, we have it in our power to determine such an arrangement as shall render the apparatus practically applicable. It is readily seen that if $v=V$ and $x=y$, a pendulum would be constructed more than twice the length of ordinary pendulums, which would occasion some inconvenience. Making, however, $x=\frac{1}{10}y$ and $y=$ a metre or a little more, we may give to the spherical body A a radius of five centimetres. The volume of this body would then be 524 cubic centimetres, and weigh 136 grammes (2100 grs.): the bob of lead should be $\frac{1}{10}$ of the above volume, would contain 52.4 cubic centimetres, and weigh 595 grammes (9189 grs.), or 22 Milanese ounces, a weight sufficient to sustain the motion of the pendulum.

It is to be observed that the two masses have been considered as spherical, merely to simplify the calculations; but, in daily use, it would be proper to preserve the lenticular form of the bobs, which, occasioning much less resistance from the atmosphere, permits the application of a smaller force in the construction of clocks, and the attachment of pendulums to them.—*Giornale di Fisica*, viii. 338.

4. *Solution of a Problem relative to Terrestrial Magnetism*, by M. Poisson.—The magnetic action of the earth has not either the same direction or intensity on all the points of its surface. In the same place the direction of this force is subjected to diurnal and annual inequalities, and to other variations, which, though more slow, are of greater extent. All these changes in the direction, of which the cause and laws are still unknown, are indicated by those of the dipping-needle or the compass, which take, at every moment and in every place, the direction of the magnetic force of the earth, or its horizontal resultant, whatever is the nature or the degree of magnetization of the needles. The intensity of this force is measured by the oscillations of a magnetic needle on the one side and the other, of its position of equilibrium; but as their duration depends upon the action of the earth at the moment of observation, and the magnetic state of the needle, it is necessary, for the purpose of understanding the changes produced by the first cause, always to employ the same needle, and at the same temperature: for experiment has shewn that the magnetic power of a steel needle augments as the temperature diminishes, and diminishes as the temperature is raised. This circumstance prevents the use of the means described in discovering changes of intensity, which become evident only after a long period, and which may for this reason be called *secular varia-*

tions. We are not certain, in fact, of finding, after a long period, the same needle that was originally used; and even if found, it may be doubted whether it has retained its original state of magnetization. The difficulty is not less which we find in endeavouring to construct a steel needle, perfectly identical, both in the substance and the distribution of magnetism, with a needle of which the description, the chemical analysis, and the process of magnetization have been given. It will nevertheless be interesting to leave to our successors a certain method of comparing the magnetic state of the globe with its present state, and of ascertaining whether the action of the earth upon the needle is augmented or diminished by time. Philosophers have already thought upon this problem. The following is the method I propose for resolving it, the accuracy of which may be ascertained at present.

I suppose that a needle is magnetized to saturation or otherwise, and freely suspended by its centre of gravity, so that it may take the direction of the terrestrial magnetism at the time and place of observation. It is to be made to oscillate about this position, and the number of vibrations counted in a given time, so that the time of each oscillation may be known. The same operation is repeated with a second magnetic needle, similarly suspended with the first. The centres of gravity of these two needles are then to be placed in the same right line parallel to the magnetic action of the globe: in consequence of this force, and their mutual action, the lengths of the two needles are directed according to this parallel; the needles are then to be oscillated successively on one side and the other of the magnetic meridian, subject to the united actions of the earth and the other needle, and the duration of each of these new observations is to be observed. Then the distance between the centres of gravity is to be measured, and the momentums of inertia relative to their respective axis of rotation passing by these points calculated. In this way the value of seven quantities will be obtained, namely, the distance between the two centres of gravity, the two momentums of inertia, and the durations of four different oscillations, to which, for the purpose of greater accuracy, is applied the correction relative to their amplitude, according to the same rule as that applied in ordinary experiments on the pendulum. Now there exists a certain function of these seven quantities which I have designated by F in my Memoir, the value of which does not depend upon the two needles employed, but only upon the intensity of the terrestrial magnetism. Only an approximative value of this function F can be obtained; but I have given the means of calculating it to any degree of approximation required, so that no errors are to be feared, as to its value, except such as belong to the experiments, and, in the present state of experimental science,

these must be very small, and will probably be diminished by more perfect modes of observation.

Now suppose that many philosophers make this experiment in the same place and at the same time, but employing needles which differ either in the nature of the steel, or in temperature, or in degree of magnetization, or even in using needles of cobalt and nickel instead of steel needles, still all may deduce from their observations the same value of the quantity F. All that is requisite is, that the state of magnetization of the needles do not change during the experiment, *i. e.*, that the distribution of magnetism does not change by the mutual action of the needles joined to that of the earth, an effect which might happen if the needles were formed of soft iron, or of any other substance of which the coercive force was not considerable. With this precaution it will be important to verify, in its utmost generality, this property of the function of F.

This done, if the same experiment be repeated at a period very distant from the present,—a hundred years hence, for instance,—it may be rigorously ascertained that the magnetic power of the earth has changed in intensity, or that it continues the same, according as the value of F is found to be different from or the same with its present value; and in the case of variation, the ratio of the future value of F to its present value will indicate the ratio of the corresponding magnetic forces of the earth, the second ratio being equal to the square root of the first.

The magnetic power of the earth, like that of all other magnets, is the product of two factors, one of which depends upon the distribution of the two fluids, the *boreal* and the *austral*, in its interior; and the other, common to all substances capable of magnetization, expresses the intensity of attraction and repulsion at a unity of distance, and between quantities of fluid, also taken as unity. It may, therefore, vary for two different reasons; because the particular magnetic state of the terrestrial spheriod has changed, or because the mutual action of the particles of the magnetic fluid weakens or strengthens in all substances capable of retaining magnetism: it may be observed, that in these two cases the change of the power of the earth is indicated by a change in the quantity F.

I have supposed that two dipping-needles would be used in the experiment I have proposed, freely suspended by their centres of gravity, and capable of oscillating in any plane; but if is found more convenient, two horizontal needles may be used, being placed in the same magnetic meridian, and on a line with each other. The quantity F will then depend on the action of the earth, decomposed horizontally, or multiplied by the co-sines of magnetic inclinations, of which the variation must be known for the estimation of the intensity.

(The Memoir, from which this is an extract, is part of the *Additions to the Connaissances des Temps* for 1828.)

P.S. Since the reading of the Memoir at the Academy, I have thought that the mutual action of the needles might be augmented, and, consequently, the precision of the method increased, by placing the centres of suspension in the same vertical, and during the oscillations of each needle turning the fixed needle, so that the contrary poles should correspond. But it is for those philosophers who make the experiment, to choose the most convenient means of execution. The principle which I have stated consists in this, that if two magnetic needles oscillate in consequence of their mutual action and the action of the earth, there will always be a certain quantity which depends upon the latter action. Whatever is the degree of magnetization and the nature of the isolated needle, its direction depends upon the magnetic force of the earth ; and also in the case of two needles, the quantity of which we speak depends on the intensity of the same force. —*Ann. de Chim.* xxx. 257.

Note by M. Arago.—For the purpose of resolving the question considered by M. Poisson, in the above Memoir, I proposed to the Bureau des Longitudes (Nov. 16), a process, by the aid of which, it appeared to me, the same degree of magnetism might be given to steel needles at any period. This process is founded on the property possessed by a magnetic needle, when placed in the neighbourhood of a rotatory metallic plate, of turning with it with a force proportionate to the intensity of its magnetism. When the experiment is made in a plane perpendicular to the magnetic meridian, terrestrial magnetism has no influence over it, and then the small weight necessary to be attached to the extremities of the needle, to enable it to take, when the plate is revolving with a certain velocity, a deviation of 10°, 20°, 30°, *&c.*, will be the measure of the magnetic intensity of the poles. If it is admitted that science is capable of reproducing, at pleasure, iron exactly similar in properties, the angular deviation occasioned by a mass of this metal may be substituted for the deviation occasioned by rotation. However, a needle proved by the last process will become an excellent means of appreciating the periodical or secular changes to which the magnetism of our globe is subject. I do not at present give more extensive details, not being able to express in *figures* the precision of which the method is susceptible ; but I shall make it the subject of a particular memoir, if, as I hope, the experiments I am engaged upon prove favourable. —*Ann. de Chim.* xxx. 263.

5. *Hardening of Steel Dies.*—Mr. Adam Eckfeldt is stated to be the first who employed the following successful mode of hardening steel dies. He caused a vessel, holding 200 gallons of water, to be placed in the upper part of the building, at the

height of forty feet above the room in which the dies were to be hardened; from this vessel the water was conducted down through a pipe of one inch and a quarter in diameter, with a cock at the bottom, and nozzles of different sizes, to regulate the diameter of the jet of water. Under one of these was placed the heated die, the water being directed on to the centre of the upper surface. The first experiment was tried in the year 1795, and the same mode has been ever since pursued (at the Mint) without a single instance of failure.

By this process the die is hardened in such a way as best to sustain the pressure to which it is to be subjected; and the middle of the face, which by the former process was apt to remain soft, now becomes the hardest part. The hardened part of the die so managed, were it to be separated, would be found to be in the form of a segment of a sphere, resting in the lower softer part as in a dish; the hardness, of course, gradually decreasing as you descend towards the foot. Dies thus hardened preserve their forms until fairly worn out.—*Franklin's Jour.* i. 98.

6. *Cutting of Steel by Iron.*—Having occasion a short time since to cut a plate of cast-iron, three-eighths of an inch thick, it was thought that the plan recommended for cutting steel by iron might succeed in this case. Accordingly a disc of sheet-iron was placed on an axis, and adapted to a water-lathe, in a manner to revolve with great rapidity. This disc would cut hardened or soft steel, or wrought-iron, with much facility, but produced not the slightest effect on the cast-iron, though the latter was very gray and soft. I confess I am quite at a loss to explain this difference in the action of the disc.—Extract from a letter written by Mr. Dolittle, Bennington Iron Works, Jan. 1826.—*Sill. Jour.* x. 397.

7. *Iron-Wire Suspension Bridge, at Geneva.*—A second suspension bridge has been constructed, at Geneva, of iron wire, as successfully as the first *. It extends in the same manner over the ditches of the fortifications; its length is 82 metres (269 feet,) that being, however, divided into two portions by an intermediate support of masonry. Its width is two metres (6.56 feet.) It descends from the town side outwards, and also passes obliquely at an angle of 60° from the abutments, circumstances which raised the expense to 30,000 francs. The suspension cables are four in number, and contain each 135 wires running the whole length; the wires are held at the extremities in a hollow cone, and the flexure of the cables is one-twelfth of the distance between the points of attachment. The bridge, when finished, was laden for trial, with stones, timber, *&c.*, equal in weight to that which would have been occasioned by covering it with people,

* See Vol. xvi. p. 369; and xvii. 147.

which trial it bore without the slightest derangement.—*Bib. Univ.* xxi. 74.

8. *Iron-Wire Suspension Bridge across the Rhone.*—A bridge of this kind has been constructed by M. Seguin across the Rhone, between Tournon and Tain. A mass of masonry has been raised in the middle of the river upon piles, and on each bank has been constructed a strong abutment in stone. These erections divide the width of the river into two equal parts of 100 metres each (328.1 feet), and upon each of them has been raised a thick support, of a height so calculated as to bear the two ends of the chains on which the platform of the bridge rests, suspended by six bundles of iron-wire on each side, arranged one above the other in vertical planes, at a distance equal to the width of the bridge. The wires are a line in diameter, and each bundle or cable contains 100 wires; from each cable descends vertical bundles of sixty wires each, which at every metre support the pieces of wood, on which is placed the platform of the bridge.

The platform is sufficiently wide in the middle to allow the free passage of a carriage of the largest size, and on each side is a foot-path of thirty inches wide. At the distance of twenty metres from the central pile, the road-way gradually widens, so that, when over the masonry, it is competent to contain two carriages at once, and thus facility is afforded for the passing of carriages on the bridge, without permitting more than one at a time on the suspended part.

The end of each cable, after having passed over the supports at the extremities of the bridge, descends along the masonry, and is made fast to strong imbedded cast-iron plates. The cables which proceed from Tournon rise before the town, pass over the support, proceed to the middle support, and having crossed it, are made fast to it on the Tain side; and those cables which pass from Tain are in like manner made fast to the central pile on the Tournon side. The bridge was opened to the public on September 1, 1825.—*Bib. Univ.* xxi. 84.

9. *The Litrameter.*—The litrameter is an instrument invented by Dr. Hare, for the estimation of the specific gravity of fluids, and is constructed upon the principle, that when columns of different liquids are elevated by the same pressure, their heights must be inversely as their gravities. Two barometer tubes are therefore communicated above with each other; and with a syringe, or other apparatus by which the air can be withdrawn from them, they descend into two cups intended to contain the fluids to be compared: these being put into the cups, and the pressure removed in part from within the tubes by the piston, or other apparatus, the fluids ascend, and their specific gravities are

deduced from an estimation of the heights of the column as measured by a vernier.—*Franklin's Journal*, i. 157.

10. *Hare's Chyometer.*—Dr. Hare, of the university of Pennsylvania, has lately contrived a mode of measuring fluids by a rod or piston passing through a collar of leathers into a tube, and expelling from it the contained fluid; the quantities are measured by degrees marked upon the displacing-rod, and ascertained with additional accuracy by means of a vernier. The instrument is called a chyometer, and is, by Dr. Hare, considered as very much facilitating the processes by which the specific gravity of fluids is ascertained. He has also applied the same mode of measurement advantageously to eudiometers; but we have not room at present to go into detail respecting these instruments.—*Franklin's Journal*, i. 45.

11. *Stereotype Printing.*—A new and, as it is said, improved method of stereotyping has been announced in the *Gazette de Munich*. It is the invention of M. Senefelder, to whom the world is indebted for the art of lithography, and is as follows: A sheet of common printing-paper is covered with a layer of earthy matter (query plaster or clay), previously mixed with a sufficiency of water, half a line in thickness. In about half an hour it assumes the consistency of paste, and is then put into the frames over the type, composed in the ordinary way, but not inked; in this way the printing is modelled, or engraved, in the paste above. These sheets are then dried on a stone plate, and the fused stereotype metal poured over them, the writing will then be obtained in relief on a thin plate of metal, the characters being equally well formed with the original type. The proofs taken from these stereotype plates do not differ from those taken from the form of moveable characters. The author of the discovery proposes to reveal his process minutely, so soon as he has obtained thirty subscribers at 100 florins each. The expense of the apparatus required for making the castings, he estimates at 100 florins, or about 11*l.* 3*s.* 8*d.*, and that of the paper covered with the earthy paste at six kreutzers, or 2.68 pence per sheet.

12. *Preparation of Quills.*—The following is the manner in which M. Schloz of Vienna proceeds in the preparation of quills for writing, by means of which he renders them more durable, and even superior to the best Hamburgh quills. For this purpose he makes use of a kettle, into which he pours common water, so as to occupy the fourth part of its capacity; he then suspends a certain quantity of feathers perpendicularly, the barrel lowermost, and so placed, as that its extremity only may touch the surface of the water; he then covers the kettle with a lid pro-

perly adjusted, boils the water, and keeps the feathers four hours in this vapour-bath. By means of this process he frees them of their fatty parts, and renders them soft and transparent. On the following day, after having scraped them with the blade, cut the nibs, drawn out the pith, and then rubbed them with a bit of cloth, he exposes them to a moderate heat. By the day after, they are perfectly hard and transparent, without, however, having the inconvenience of splitting too easily.—*Edin. Phil. Jour.* xiv. 376.

13. *Baltimore patent Roofing.*—This roofing consists of oil-cloth made with a thick canvass, and is found to be very durable, very water-tight, and easily preserved in order. The roofs which are covered by it should have an inclination of at least 6°, and the oil-cloth should be laid on boards, close together. It is also necessary to give it annually a coat of *paint-oil.* Two or three gallons are sufficient for a house of a common size.

Floor-cloth and oil-cloth has in this way been in use several years with perfect success.—*Franklin's Journal*, i. 172.

II. Chemical Science.

1. *Refractive Power of Gases.*—The following table of the refractive power of gases at the same temperature, and under the same pressure, that of air being taken as unity, is from a Memoir by M. Dulong, inserted in the *Annales de Chimie*, xxxi. 154 :—

	Refractive Power.	Density.
Air	1.	1.
Oxygen	0.924	1.1026
Hydrogen	0.470	0.0685
Azote	1.020	0.976
Chlorine	2.623	2.470
Oxide of azote	1.710	1.527
Nitrous gas	1.030	1.039
Muriatic acid	1.527	1.254
Oxide of carbon	1.157	0.972
Carbonic acid	1.526	1.524
Cyanogen	2.832	1.818
Olefiant gas	2.302	0.980
Gas from stagnant water / Carburetted hydrogen	1.504	0.559
Muriatic ether	3.720	2.234
Hydrocyanic acid	1.531	0.944
Ammonia	1.309	0.591
Phosgene gas	3.936	3.442
Sulphuretted hydrogen	2.187	1.178

	Refractive Power.	Density.
Sulphurous acid . . .	2.260	2.247
Sulphuric ether . . .	5.197	2.580
Sulphuret of carbon . . .	5.110	2.644
Proto-phosphuretted hydrogen	2.682	1.256

The vapours of muriatic ether, sulphuric ether, and sulphuret of carbon, were taken at a degree of density two or three times less than that corresponding to the maximum relative to each observation. The numbers contained in the preceding table are therefore comparable with those of permanent gases. In taking these same vapours at their maximum of density, their refractive powers were found to be as follow :—

Muriatic ether	3.87
Sulphuret of carbon	5.198
Sulphuric ether	5.290—*Ann. de Chim.* xxxi. 166.

Conclusions relative to the refractive Power of Gases.—It results (from the researches) that the capacities of bodies for heat, and their refractive powers, do not not belong, as has been supposed, to the same order of causes. The capacities have an evident relation to the masses of the molecules : the refractive powers appear to be independent of them.

No simple ratio exists between the refractive powers of elementary and of compound substances, even when these properties are observed in circumstances where the molecular action can be most readily compared, and where the form and arrangement of the particles cannot exert any influence.

The variations in the velocities of light passing through the different gases, considered at the same temperature and pressure, appears to depend upon the peculiar electric state of the molecules of each kind of matter. Reasoning on the theory of undulations, which seems to accord best with these new ideas, the velocity of light is more powerfully diminished according as the molecules are more strongly positive.—*Ann. de Chimie*, xxxi. 180.

2. *On the Crystallization of Minerals, by* M. Vincent.—Some years since the Berlin Academy proposed as a prize subject, the discovery of a connexion between the crystalline form and chemical composition of minerals. The prize was adjudged to a Memoir by M. A. F. Kupffer, in which the author deduced, from an examination and comparison of a considerable number of minerals taken from different systems of crystallizations, the existence of the following formula :—

$$\frac{p, s}{y} = \frac{p' s'}{y'} \quad (1.)$$

in which y, y' represent the volumes of the primitive forms of two substances taken from the same system, the axes being supposed

equal s, s' the specific weights of the two substances, and p, p' the respective weights of their atoms.

Although the work of M. Kupffer has been rewarded by the Academy, and an extract from it has been received into the *Annales de Chimie et de Physique*, it may be considered by some that the law has not been verified on a sufficient number of minerals to merit full confidence: other objections may also be raised, perhaps not without foundation. Without however prejudging the question, such remarkable consequences may be deduced from the law, that I have thought proper to make them known, with the view of inducing those persons who are favourably circumstanced to submit the law to new proofs, either for its confirmation or destruction.

It may be remarked, in the first place, that the absolute dimensions of a primitive form are entirely arbitrary, and that their ratio only is determined for each substance; hence it results that, in place of supposing equal axes in the two substances compared, we may suppose them respectively equivalent to a and a' : if v and v' are the volumes of the corresponding primitive forms, we shall have $y = \frac{v}{a^3}$, $y' = \frac{v'}{v'^3}$; and the formula of M. Kupffer will change into the following $\frac{psa^3}{v} = \frac{p's'a'^3}{v'}$ (2).

But, as it is arbitrary, take primitive forms which contain the same number n of atoms: let P and P' be the absolute weight of these primitive forms, we shall have $P = np$, $P' = np$; but we have also $P = sv$, $P' = s'v'$, therefore $np = sv$, $np' = s'v'$, which changes the formula (2) into this $s^2 a^3 = s'^2 a'^3$ (3), that is to say, that if of two substances belonging to the same system of crystallization we take primitive forms containing the same number of atoms, *the cubes of the axes are in the inverse ratio of the squares of their specific weights.* This law is that of M. Kupffer, the form only being changed.

Contracting the circumstances, suppose that the primitive forms are geometrically similar, as for example two cubes, we shall have $v : v' :: a^3 : a'^3$ and the equation (2) will be reduced to $ps = p's'$ (4), that is to say, that *in crystalline substances of the same primitive form, the specific weights are in the inverse ratio of the weights of the atoms*, a result which may be immediately deduced from (1) by making $y = y'$.

If we eliminate s in (3) and (4) we find that $p^2 : p'^2 :: a^3 : a'^3$ (5), *the squares of the weights of the atoms, are proportional to the cubes of the axes of the primitive form.*

Finally, the axes of the two primitive forms being, in our hypothesis, proportional to the respective distances of the atoms in the two substances, we perceive that *the cubes of the respective*

distances of the atoms in two substances of the same primitive form are proportional to the squares of the weights of these atoms, or in the inverse ratio of the squares of their specific weights, which furnishes a very simple means of calculating the ratios of the molecular distances of two substances when we know them to have the same primitive form. Thus, for example, copper and silver both crystallize in cubes, their molecular distances being to each other as 136 : 121, or as 9 : 8 nearly.

The preceding observations will sufficiently demonstrate the importance of knowing on what foundation M. Kupffer's law stands, and consequently of its further investigation.

I shall terminate by a few words on an objection which naturally presents itself to the preceding propositions, and which at first appears to oppose their admission. "It is absurd," it may be said, "to suppose greater specific weights when the weights of the atoms are smaller;" but the force of this objection is only apparent. In fact the atoms are maintained at fixed distances for the same temperature by the equilibrium of an attractive and a repulsive force, which are probably functions of the weights of the atoms. If these two functions increase with equal rapidity, the molecular distances will be the same in all substances, and the specific weights proportional to the weights of the atoms. But, if it be admitted that the repulsive force increases with the weight of the atoms more rapidly than the attractive force, and there is nothing inconsistent in the supposition, then it may be conceived that the molecular distances should augment with the weights of the atoms, and the paradox will be explained.

Further, the objection would apply just as strongly to facts which cannot be doubted. For instance, the weight of an atom of ether is heavier than the weight of an atom of water, yet the latter is specifically heavier than the former. Mercury in vapour is lighter than water in vapour, *&c. &c.*

Finally, it must not be forgotten that the formula (4) relates only to those crystalline bodies of the same primitive form; it would therefore be an abuse of it to apply it to any substance whatever.—*Annales de Chimie*, xxxi. 104.

3. *Spontaneous Inflammation of Chlorine and Olefiant Gas.*—Dr. Silliman has had occasion to observe the spontaneous inflammation of a mixture of chlorine and olefiant gas, and warns chemists against its re-occurrence unawares. It took place apparently in consequence of mingling the gases in such a way, that the olefiant gas occupied the upper part of the receiver, and the chlorine the lower; the two being in contact, but generally very distinct from each other. After remaining in this state a few minutes a bright flash pervaded the bell-glass, which held five or six quarts. It was raised out of the water with a slight report, a dense deposit

of charcoal lined the vessel, and covered the water, and the chlorine disappeared.—*Silliman's Journal*, x. 365.

4. *Detonation of mixed Oxygen and Proto-phosphuretted Hydrogen Gases.*—If these gases be mixed in an eudiometer over mercury, their detonation may be effected with great facility, as has been remarked by M. Houton Labellardierre, by a slight difference of pressure; raising the eudiometer a few inches in the mercury is sufficient to produce the effect instantly. Hence the necessity of certain precautions when analyzing the phosphuretted hydrogen by this method, that unexpected explosions may be prevented.—*Ann. de Chim.* xxxi. 119.

5. *On the Combination of Phosphorus with Hydrogen and Oxygen.*—M. J. Dumas has undertaken a long, laborious, and, apparently, very accurate series of experiments, for the purpose of determining the proportions of the elements in the compounds of phosphorus with hydrogen and oxygen, and the following are the results at which he has arrived:—

1. Proto-phosphuretted hydrogen gas, (hydrophosphoric gas,) prepared from phosphatic acid, phosphorous acid, hypophosphorous acid, or a mixture of an alkaline phosphuret with strong muriatic acid, is always identical and perfectly pure.—2. This gas contains $1\frac{1}{2}$ volumes of hydrogen, and is composed of 6 atoms hydrogen, and 1 atom phosphorus.—3. Its specific gravity is 1.214.—4. It absorbs during its combustion sometimes 2 volumes, and sometimes only $1\frac{1}{2}$ volumes of oxygen.—5. It is completely absorbed by a solution of sulphate of copper.

6. Perphosphuretted hydrogen gas is never pure. It is always mixed with free hydrogen, but as the latter gas is not affected by sulphate of copper, the mixture may be readily analyzed by that substance.—7. It contains $1\frac{1}{2}$ volumes of hydrogen, and is composed of 4 atoms of hydrogen, and 1 atom of phosphorus.—8. Its specific gravity is 1.761.—9. It absorbs during combustion, for every 8 volumes, sometimes 15, sometimes 21 volumes of oxygen.—10. It is entirely absorbed by solution of sulphate of copper, and by many other metallic solutions.

11. Phosphorous acid and phosphoric acid contain oxygen in the ratio of 3.5.

12. The weight of the atom of phosphorus, deduced from the specific gravity of perphosphuretted hydrogen, appears to be 400. —*Ann. de Chimie*, xxxi. 113.

Note. It is necessary to remark, that 2 of M. Dumas' atoms of hydrogen are equivalent to 1 volume or 1 proportional.

6. *New Compound of Hyponitrous and Sulphuric Acids.*—Dr.

Henry has had the opportunity of examining a substance, produced during very cold weather in the leaden pipe, by which the foul air of a sulphuric acid chamber was conveyed away; the pipe was completely stopped by the substance, which resembled borax in appearance. The portion brought to Dr. Henry formed a solid mass at the bottom of a bottle, so hard that it could not be removed, except by a force so great as to destroy any crystals that might have existed. Being left in a warm room, it first became soft and pasty, and gradually a thick liquid of specific gravity 1.831 floated over the solid part. The crystalline portion was extremely acid, and stained the fingers like nitrous acid; when added to water it effervesced, producing red fumes, and occasioned a rise of above 60° in temperature; 100 grains in water, by the application of a little heat, evolved 16.6 cubic inches of pure nitric oxide. When heated alone it evolved no gas at 220°. At 280° gas came off, but even when heated *per se* to 400°, the liquid which remained gave gas when poured into water; a portion of nitrous acid came over at the same with the gas.

Being found to yield nothing but sulphuric acid, nitrous acid and nitrous gas, it was analyzed by being put into water, and the nitric oxide gas expelled and collected; the solution diluted was then neutralized by pure baryta, the sulphate of baryta separated, and the sulphuric acid estimated, and then sulphate of soda being added to the solution, the nitrate was decomposed, and the proportion of nitrous acid determined from the quantity of sulphate produced; 100 grains of the substance, according to Dr. Henry, afforded,

Real sulphuric acid . . .		68.000 gr.
Nitrous gas (16.6 cubic inches) =	5.273	13.073
Nitrous acid . . .	7.800	
Water		18.927

and he is inclined to think that, from their arrangement in the substance, it was constituted of

5	atoms Sulphuric acid	200
1	—— Hyponitrous acid	38
5	—— Water . .	45
		283

Dr. Henry considers this compound as probably the same with that obtained many years ago by MM. Clement and Desormes, by mingling sulphurous acid, nitrous gas, atmospheric air, and aqueous vapour; and also with a similar compound, produced by Gay-Lussac, by adding to sulphuric acid the product of the distillation of nitrate of lead; and he observes that it furnishes another example to those known of a weak acid serving as a base to a more powerful one.—*Ann. Phil.* N. S. xi. 368.

7. *Action of Sulphur on Sulphuretted Hydrogen.*—M. Dumas has pointed out an important action of sulphur on sulphuretted hydrogen, which, as it effects the results of certain analytical processes, should be clearly known to all chemists. It is usual to analyze carburetted hydrogen and phosphuretted hydrogen gases, by heating sulphur in them, and estimating the quantity of sulphuretted hydrogen produced, the affinities being such as to cause replacement of the carbon or phosphorous by the sulphur. He found, however, that sulphuretted hydrogen was itself affected, and changed in volume by heated sulphur; 100 parts by degrees being diminished even to 90. Hence the indication of hydrogen in this way becomes erroneous, and the process must be declared a bad one.—*Ann. de Chim.* xxxi. 116.

8. *Fluidity of Sulphur at common Temperatures.*—Having placed a Florence flask containing sulphur upon a hot sand-bath, it was left to itself. Next morning, the bath being cold, it was found that the flask had broken, and in consequence of the sulphur running out, nearly the whole of it had disappeared. The flask being broken open, was examined, and was found lined with a sulphur dew, consisting of large and small globules intermixed. The greater number of these, perhaps two-thirds, were in the usual opaque solid state; the remainder were fluid, although the temperature had been, for some hours, that of the atmosphere. On touching one of these drops, it immediately became solid, crystalline, and opaque, assuming the ordinary state of sulphur, and perfectly resembling the others in appearance. This took place very rapidly, so that it was hardly possible to apply a wire or other body to the drops quick enough to derange the form before solidity had been acquired; by quick motion, however, it might be effected, and by passing the finger over them, a sort of smear could be produced. Whether touched by metal, glass, wood, or the skin, the change seemed equally rapid; but it appeared to require actual contact; no vibration of the glass on which the globules lay rendered them solid, and many of them were retained for a week in their fluid state. This state of the sulphur appears evidently to be analogous to that of water cooled in a quiescent state below its freezing point; and the same property is also exhibited by some other bodies, but I believe no instance is known where the difference between the usual point of fluidity and that which could thus be obtained is so great: it, in the present instance, amounts to 130°, and it might probably have been rendered greater if artificial cold had been applied.—M. F.

9. *Crystallization of Sulphur.*—The peculiar arrangement of the crystals of ice in a case of hoar frost, where every crystal appeared as if it had endeavoured to recede as far as it could from

the neighbouring crystals, has been observed and described by Dr. Mac Culloch, at page 40, vol. xx. of this *Journal*. A similar effect may be pointed out as exhibited in crystallized sulphur. The man who melts and purifies the sulphur at the gunpowder works at Waltham Abbey is very expert in introducing wires or wooden forms into the melted sulphur, which, acting as nuclei cause a crystallization of sulphur as the whole cools, and then, by letting out the liquid portions, the substances introduced are found covered with acicular or prismatic crystals, at times an inch or more in length. In this way he forms letters, names, and the figures of animals, *&c*. In all these cases the arrangement noticed by Dr. Mac Culloch may be observed; and wherever an angle occurs, the convergence of the crystals is very striking and beautiful.

10. *On Metallic Precipitations*.—Relative to the peculiar case of the precipitation of copper described by M. Clement*, M. Taillefer quotes the following similar instances. A person of Dijon, who separates the metal from the ashes and crucibles of jewellers, gave him some solution in which he suspected a small portion of gold and silver still remained; it appeared, however, to contain nothing but copper in solution in nitric acid: it was left for several days in a large glazed earthen bowl, and then, when decanted, was found to have deposited a network of copper, slightly adherent, and of which the ramifications closely followed the clefts in the glaze. This effect is explained in the following way: the vessel had previously been used in a kitchen, and having been on the fire, the glaze was cracked most at the bottom; these cracks, it is supposed, had by capillary attraction retained animal or vegetable matter, and this, by its action on the solution of copper, had reduced and separated a part of the metal.

The following is another instance of the precipitation of copper without the help of another metal: such instances are, however, sufficiently abundant. Cream of tartar dissolves a large quantity of black oxide of copper; if the solution be diluted, and then heated moderately, there will be deposited, in the course of some hours, a finely-divided red powder, which dissolves in nitric acid, disengaging nitric oxide, and indeed having all the characters of reduced copper. This deposit increases to a certain point, beyond which no further change of the kind takes place; the solution becomes, from concentration, thick, and at last solid.—*Annales de Chimie*, xxxi. 103.

11. *Sulphates in Soot*.—M. Braconnet having analyzed several varieties of soot, as that from a wood-fire, lamp-black, &c., con-

* See Vol. xix. page 154.

cludes, amongst other things, that all soots essentially contain several sulphates. The presence of a notable quantity of sulphate of ammonia, amongst other sulphates, in lamp-black, renders that substance unfit to be used, as has sometimes been done, in the reduction of metals, when it is wished to obtain them pure, and not at all sulphuretted.—*Annales de Chimie*, xxxi. 37.

12. *Presence of Strontian in Sulphate of Baryta.*—M. Baruel has remarked the presence of strontian in sulphate of baryta, in such quantity, that when, in the conversion of the sulphate into a nitrate by the ordinary processes, the mother-water from which the nitrate had been crystallized was itself purified in part, and crystallized, it gave abundant crystals of nitrate of strontian, amounting to a thirtieth part in weight of the nitrate of baryta obtained. The substance he used was the crystallized sulphate of baryta of Auvergne.—*Annales de Chimie*, xxxi. 219.

13. *Influence of Sugar in the Precipitation of Iron by Ammonia.*—The power possessed by tartaric acid of preventing the precipitation of iron from its solution in muriatic acid by ammonia, is now well known, from the observations of M. Rose and others. M. Peschier has remarked a similar effect produced by sugar. Peroxide of iron being dissolved in nitro-muriatic acid, with the addition of sugar; ammonia, on being added, produced no effect. A solution of iron in muriatic acid, to which sugar had been added before ebullition, presented the same appearances with ammonia; but if the muriate of iron and sugar had not been boiled together, then the ammonia precipitated the oxide. Gum-arabic, which scarcely differs from sugar in its composition, has not this property.—*Annales de Chimie*, xxxi. 297.

14. *Peschier on Titanium in Felspar and Serpentine.*—M. Peschier, still examining and pursuing the methods by which he is enabled to find titanium in considerable quantities, where MM. Vauquelin, Rose, and others cannot find it, has given another paper to the Geneva Society of Philosophy and Natural History, on the chemical composition of felspar and serpentine. The conclusions to the memoir are:—1. That titanium forms a consituent principle of felspars and serpentines. 2. That the analysis of serpentines cannot be exact, except in employing the process, modified in such a way as to insulate the titanium *. 3. That an alkaline principle exists in serpentines, as well as in the stones to which they are analagous.

"In one word," it is said, "my researches demonstrate that the greater number of the stones of primitive mountains contain

* See Vol. xix. page 157.

titanium in the number of their constituent principles, and that this substance is more generally distributed in nature than is supposed."—*Ann. de Chim.* xxxi. 294.

15. *Explosion of Pyrophorus.*—Dr. Hare prepares pyrophorus in the following manner: Take lamp-black three, calcined alum four, and pearl-ashes eight parts, mix them thoroughly, and heat them well in an iron tube to a bright cherry-red for one hour. This pyrophorus rarely fails. When well prepared, and poured out upon a glass plate, and especially when breathed upon, it kindles with a series of small explosions, a little like those produced by throwing potassium upon water. There is even danger to the face and eyes from the number and rapidity of these explosions.

A preparation of this substance having been made, was left eight or ten days, well corked in the iron tubes, and being then opened for transference to another vessel, a common ramrod was introduced to loosen the pyrophorus, the motion of which produced considerable friction; when an explosion took place as loud as a common musket, by which the contents of the tube were blown out in a jet of fire two or three feet long, scorching the hair and eyebrows of the person conducting the operation, and a violent jerk was given to the hand that held the ramrod; a glove with which the hand was fortunately covered was burnt in several places to a crisp. On putting the ramrod into a second tube, containing pyrophorus, and very cautiously and gently touching the substance with it, a second explosion took place violent as the first; it was not thought prudent to repeat the experiment with the third and larger portion. This pyrophorus had been observed to be unusually good, and, when breathed upon in the air, kindled in many places at once with a slight explosion. The tubes, well stopped, had stood within eight or ten feet of the laboratory fire, and could not have imbibed moisture.—*Silliman's Journal*, x. 366.

16. *On a Filamentous White Substance, found in Cast-Iron.*—M. Vauquelin has examined a piece of cast-iron, given to him by M. Mollerat Guyon, which was covered over the larger part of its surface by a white substance, formed of silky crystals, apparently coming out of the iron, and resembling bundles of some kinds of amianthus, or plumose alum. They were perfectly white, and extremely light; upon chemical examination it proved to be pure silica. M. Vauquelin had occasion to examine, some years ago, a similar substance found in a blast furnace, and though potassium and sodium were then known, silicium was not, and the appearances were difficult to explain. It seemed to require a supposition that silica was, to a certain degree, volatile, and even then

it was difficult to explain. Now that it is known silicium may be contained in considerable quantity in pig-iron, it is easy to comprehend that this metal, in such combination, exposed to a high temperature, and in contact with air, may be reduced to vapour, and in that form come to the surface of the iron, and there burn and crystallize. The specimen referred to is very proper to illustrate this effect. Its surface is ductile, whilst its centre is still brittle.—*Ann. de Chim.* xxxi. 333.

17. *New Manufacture of Glass.*—M. Legnay has invented a new method of manufacturing glass, without the use of free alkali. He has obtained a *brevet d'invention* in France, and the following is the process:—Take 100 parts of dried sulphate of soda, 656 parts of silica, and 340 parts of lime which have been exposed to the air. All these materials must be mixed with much exactness. The furnace and pots are to be heated till full red, when the mixture, in small balls, should be charged into the pot, until the latter is full. The mouth of the pot should then be stopped up, and, with its contents, introduced into the furnace, and as soon as it is perceived that the materials have sunk in the pot, more of the same mixture must be put in, until the pot is filled with a melted vitreous substance. A strong fire must be continued, in order to obtain a complete fusion in as little time as possible. When the fumes diminish, small portions must be taken out at different times, to ascertain whether the glass be sufficiently refined, which generally happens in about 22 hours. This glass is then fit for use; it may remain double the time in the furnace without risk.

Another mode proposed is—to take 100 parts of well-dried muriate of soda, 123 parts of silica, 92 parts of lime which has been exposed to the air, well mixed together, and fused in the way above described; in 16 hours a good glass will be obtained, which will be fit for use for any purpose that may be required.—*Description des Brevets, &c.*

Other proportions.—100 dried muriate of soda; 100 slacked lime; 140 sand; from 50 to 200 clippings of glass of the same quality.

Or, 100 dried sulphate of soda; 12 slacked lime; 19 powdered charcoal; 225 sand; 50 to 200 broken glass. Again, 100 dry sulphate of soda; 266 slacked lime; 500 sand; 50 to 200 broken glass.—*Annales de l'Industrie Nationale.*

18. *On the Fabrication of Puzzolana, Hydraulic Cements, &c.*—The following experiments have been made, and the conclusions drawn, by M. le Générale Treussart: they are of considerable importance in their relation to the durability, not merely of edifices constructed in the water, but to the improvement of ordinary mortar.

An alum-clay is obtained at Strasburg of a dark colour, but which heated passes by various shades of blue to a white colour; portions of this earth, of the size and form of a brick, were heated in an alum-furnace in contact with air, whilst other similar portions were heated in a lime-furnace, in which the access of air was diminished by covering the top of the furnace, so that no more should pass than was required for combustion; this was repeated several times, and portions being taken from the two furnaces, which by their colour appeared to have undergone equal calcination, mortars were made with them, one part of good common lime, and two parts of the pulverized clays being used. On examination, it was found that the mortar specimens, containing the clay calcined in the alum-furnace, hardened in the space of 2 or 3 days, and after a year's immersion in water, supported weights from 192 to 263 kilogrammes before they broke, whilst the others required 30 days before they were hard, and broke with weights from 20 to 25 kilogrammes. Some of them were soft even after a year's immersion in water.

A clay from Holzheim, near Strasburg, which contains no lime, but much iron, was formed into two bricks, two-hundredths of lime having been introduced into one of them; they were calcined in a lime-kiln with as little access of air as possible. A large Hessian crucible was pierced at the bottom, and then divided internally into two chambers by an upright slate full of holes: into one chamber was put pure Holzheim clay in pieces; into the other, pieces of the clay mixed with 2 per cent. of lime: the crucible was placed on the bars of a reverberatory furnace, so as to obtain a strong current of air through it and about the clay, and was then heated. In six hours it appeared by the colour that the crucible-clay was equally calcined with that from the lime-kiln; finally these four specimens were powdered, and being mixed with half their weight of common lime, were made into mortar, and were then put into water. The specimen containing the clay heated in the lime-kiln required 30 days before it hardened; that containing the clay, with 2 per cent. of lime, heated in the lime-kiln, hardened in 17 days; that containing the unmixed clay from the crucible hardened in 5 days; and that mixed with 2 per cent. lime from the crucible hardened in 3 days.

From these experiments it is concluded, that the air exerts great influence in the calcination of clays, and M. Treussart considers the effect as exclusively produced on the alumina. In consequence of this opinion, he calcined alumine in a current of air, and another portion in a lime-kiln, and then mixed them with lime made from white marble; the first hardened very much quicker than the latter; and it was observed also, that the alumine calcined in the air dissolved more rapidly in sulphuric acid than that from the lime-kiln. M. Treussart even concludes, that

at a high temperature the alumine in clays absorbs oxygen, and that it is this change which renders it more competent to combine with lime in the humid way.

In consequence of these experiments and views, it is proposed that when artificial puzzolanas are to be made, smooth clays containing a little lime should be taken, made into bricks, and calcined with free admission of air. Before undertaking large operations, it will be well to heat small portions of the clay for different periods of time in a small reverberatory furnace, for the purpose of ascertaining the most advantageous degree of calcination. The method of trial is to reduce these clays to fine powder, and to make them into mortars, with half their bulk, or rather less, of common lime; these mortars are to be put into glasses, and after having assumed a degree of consistence, by ten or twelve hours' exposure to the air, are to be immersed in water. If, at the end of three or four days, the mortars are so hard as, when strongly pressed by the thumb, to receive no impression, as will be the case with puzzolana or natural terras, it is a proof that a good artificial puzzolana has been formed.

It may be observed, that in the preparation of mortar to be exposed to air, expensive cements are frequently used which are of no advantage. Experience has shewn, that all these cements which have not the property of making common lime harden under water, produce no other effect in mortars exposed to the air than so much sand; whilst those which make common lime harden readily under water, produce excellent mortars in the air. Before they should be employed, therefore, in such cases, they ought to be tried as to their power of producing hydraulic cements. —*Ann. de Chim.* xxxi. 243.

19. M. Baup *on several New Substances.*—I have found a new substance in the resin of the *pinus abies*: it crystallizes in square plates, is soluble in 7½ parts of alcohol, insoluble in water, *&c.* I have found another substance in the colophane of France, which, according to appearance, is derived from the *pinus maritima*: it is crystallizable in triangular plates, soluble in 4 parts of alcohol, and insoluble in water, *&c.* These new substances act as acids; they combine as well with the alkalies as with the acids, and form true salts, of which some are soluble in water and alcohol, others in ether only. I have named the first substance, *abietic acid;* and the second, *pinic acid*, &c.

I had previously found a new substance in the resin of the *arbol a brea* (an undetermined tree from the Island of Manilla): it crystallizes in brilliant rhomboidal prisms, terminated by diedral summits; it is insoluble in water, soluble in 70 parts of alcohol; and I have named it provisionally, *bréine.* I have separated another substance from the resin of the *Amyris elemi*-

fera, which has considerable analogy with the former, but differs by greater solubility in alcohol (dissolving in 20 parts of that fluid), by its crystalline form, *&c.* It has been called *clemine*.

Whilst experimenting upon the potato, I found *solanine*. This body, which M. Desfosses discovered some years ago in the nightshade, *&c.*, must therefore be added to the constituents, of this plant. The tubercles contain less than the germs and the latter have a very acrid taste. I do not doubt that it will be found serviceable some time or other in medicine."—*Ann. de Chim.* xxxi. 108.

20. *On the Production of Colour in Substances by Acids.*—The observations by M. Colin on this subject may be found, page 181 of this volume; others have been published by MM. Bourdois and Caventou, of which the following is the pith:—The property of producing colour is not peculiar to albumen, for the same effects have been obtained by muriatic acid with other bodies. Gelatine, isinglass, cheese, glairy and coagulated albumen, fibrin, tendon, mucus, *&c.*, *&c.*, have been experimented with; all these, except gelatine, isinglass, and tendon, dissolve perfectly in cold muriatic acid; and the solution, left to itself, assumes a fine blue colour, especially when albumen is used: gelatine and isinglass dissolve in the same acid, but produce no colour in several days; the solution of tendon becomes of a reddish-brown colour after some hours.

Strong sulphuric acid yields a brown colour; acetic acid, phosphoric acid, chlorine and iodine, produce no change of colour; nitric acid, and, in a smaller degree, muriatic acid, produce the usual yellow colour.

It is remarkable that the change produced by muriatic acid and glairy albumen depends very much upon temperature. At a temperature of 46° or 48° Fahr., no coloration was produced, but being taken into a temperature of 73°—77° Fahr., the blue colour was developed the same day.—*Ann. de Chim.* xxxi. 110.

III. Natural History.

1. *On the Secretion of Bile.*—To determine whether the bile is secreted from arterial branches, or from those of the vena portæ, it is necessary to tie the excretory ducts, and the vessels which carry both kinds of blood to the liver. The ligature of these vessels, which has been considered impossible, may easily be performed in rabbits; but the bile being of a light colour, the results are not conclusive. It is done with more difficulty in pigeons on account of the hepatic artery, but in consequence of

the positive consequences which may be drawn from the experiments, the following were made with these birds:—

i. *Ligature of the excretory vessels.*—The liver swells and becomes filled with globules of a bright green colour, which colour spreads over the whole surface of the liver and neighbouring parts. In ten or twenty hours the animal evacuates by the anus matter absolutely green, of the colour of the bile in the gorged liver, which colour of the excrements increase until the death of the animal; and it was found that the green matter by which it was produced only exists in the cloaca. This fact with the observation of Prevost and Dumas, who have succeeded in increasing the biliary secretion by interrupting that of the urine, demonstrates that the kidney and liver assist each other more or less respecting the excretions of their respective products, when it cannot take place by the natural channel.

ii. *Ligature of the excretory ducts and the hepatic artery.*—At the end of twelve hours the surface of the liver and neighbouring parts receives a colour; the canals become filled, and announce the presence of bile. In twenty hours the liver contains a great quantity of green granulations, more numerous on the left than on the right side; the cloaca also contains green matter, as in the last instance. If the animal lives for forty hours, the green colour of the liver and excrements deepens. These experiments seem to prove that the separation of bile follows, and for a long time after the liver has been deprived of arterial blood.

iii. *Ligature of the hepatic artery alone.*—In this case the liver does not become gorged, the excretory ducts being open. After death it is found that the secretion of bile has continued since it is found in the ducts, and also the matters contained in the intestines present their usual bilious colour.

iv. *Ligature of the roots of the vena portæ, and of the excretory ducts.*—The liver is then directly deprived of its colour, and has only a pale rose tint, like the lungs of the same bird; no trace of bile is to be found; the intestine contains a grey or whitish pulp; the cloaca is full of excrement, without the least trace or mixture of green; and notwithstanding which, many pigeons have lived in this state for thirty-six hours. Tying only the principal trunk of the vena portæ to permit the gastro-hepatic veins to enter; the right lobe which receives them, is at the end of fourteen hours in its natural state; whilst the left lobe is without colour, and presents, on its outside, merely a few traces of bile.

From these series of experiments it may be concluded,—1. That the ligature of the hepatic artery does not impede the secretion of bile. 2. That the presence of bile becomes evident when the excretory ducts are tied. 3. That the blood of the vena portæ is that which furnishes the elements of bile, since by tying those vessels the secretion is arrested.—*Annali Universali, Decem.*

2. *Experiments on Poisoning, by* M. Segalas.—M. Segalas communicated to the Academy of Medicine the results of some experiments, tending to prove that poisons rather produce their effects through the medium of the vessels than of the nerves. The following are some of his results:—1. Having cut the spinal marrow of an animal so as to render it paralytic, and having placed some alcoholic extract of nux vomica in the paralysed parts, he perceived that tetanus came on just as quickly and powerfully as if the nervous system had been entire. 2. Having, on the contrary, left the spinal marrow untouched, but prevented the blood which returned from the part where the poison had been lodged from being carried to the heart, he observed that the poisoning did not take place. 3. Tetanus appeared to come on as quickly when he injected the poison into the branchiæ, although the eighth pair of nerves were divided. 4. The nux vomica placed in the thigh of an animal rendered paralytic by the division of the spinal marrow, produced tetanus not only in the trunk and upper extremities, but also in the paralyzed parts. 5. The same result takes place in whatever part the poison has been placed; only the contraction of the paralyzed muscles is slower, and seems only to occur in proportion as the blood conveys the poisonous matter to the nerves which animate them. 6. Having injected the poison into the crural artery of a paraplegic animal, its effects were manifested in the like manner: the convulsions commenced in the thighs, and only became general after the lapse of time judged to be necessary for the conveyance of the poison to the spinal marrow.

M. Segalas concludes from his experiments, that the voluntary muscles can contract themselves in certain cases, independently of the action of the spino-cerebral system. In these experiments he has often designedly made the division of the spinal marrow at different points, but most commonly on a level with the last vertebra of the neck, or the first of the lumbar vertebræ, and this has produced no modification of the phenomena.—*Med. Journal*, lv. 516.

3. *Cutaneous absorption.*—The following experiments on this subject have been made by M. Collard:—1. Having immersed his hands as far as the wrists in hot water for two hours and a half, he found that the veins of the hand and fore arm were swelled, and also the lymphatic ganglions in the axilla. 2. Having kept his hands for an hour in a vessel filled with water, of which he had ascertained the capacity and surface, he found, on withdrawing them, that the vessel had lost more water than another placed as exactly as possible in the same circumstances. 3. A funnel being closed below and filled with water, the hand was applied to the upper part, the portion of skin within the funnel was gra-

dually drawn inwards, as if by the formation of a small vacuum. 4. The experiment was repeated with a funnel, the neck of which was graduated, and in which was a bubble of air, to indicate by its position any absorption; the results coincided with the last. 5. A glass syphon had its shortest leg enlarged into a funnel, mercury was placed in the bend, and the funnel extremity being filled with water, was covered by the hand for two hours; the mercury gradually approached the hand, proving, with the other experiments, as M. Collard thinks, the absorption of water by the skin.—*Archives Gen. Fev.*

4. *Laws of Mortality in France.*—M. Benoiston, of Chateauneuf, has drawn up a memoir on the changes which the laws of mortality appear to have undergone since 1755, containing, among curious and interesting observations, the following:—Of 100 infants, 50 were formerly found to die in the course of the first two years of life; the number of deaths is now reduced to 38.3, a difference which is, in a great measure, ascribed to vaccination.

Of 100 children, 55.5 formerly died before ten years of age; at present the number is 47.7.

Of 100 male children, 21.5 only reached to the age of fifty; at present the number attaining that age is 32.5.

It was formerly ascertained that the rate of annual mortality was 1 in 30, it is now 1 in 39. The births were formerly in the proportion of 1 to 25; they are now 1 to 31. Marriages were as 1 to 111; they are now as 1 to 135. The fecundity of marriages was calculated as presenting an average of four children to every married couple; and in this respect no change is found to have taken place.

Thus, it seems, the marriages have *decreased* in number; and as a consequence, although not a direct one, the births are fewer. But the term of life seems to have been prolonged, and thus the population has become greater.

5. *Animal Magnetism in France.*—A commission of the Academy Royale de Médecine has actually reported relative to animal magnetism:—1. That the judgment given in 1784, by the members of the Academy of Sciences, and of the Royal Society of Medicine, charged with the examination of the subject of animal magnetism, ought not to interdict a fresh examination; since, in matters of science, a first judgment has been too often found defective; and because the researches made by them had not been made with all the care that the habit of experimenting has since introduced. 2. That the magnetism on which judgment was pronounced in 1784 differs entirely in theory, practice, and phenomena, from that now to be considered. 3. That magnetism having now fallen into the hands of learned men and physicians,

and being a special subject of study in most of the colleges of medicine in other countries of Europe, it is for the honour of French physicians not to be behind those of other nations. In fact, that considering magnetism as a secret remedy, it is not only an amusement but a duty of the Academy to take notice of it.

6. *Biliary Calculus from a Sow.*—The biliary calculi of oxen, cows, horses, &c. have hitherto presented only a yellow substance peculiar to the bile of these animals. In the present instance, the calculus differed in composition from all that had previously been observed, particularly in containing cholesterine. It was analysed by M. J. L. Lassaigne, and was found to consist of

Cholesterine	6.00
White resin	44.95
Bile	3.60
Animal matter and altered green resin	45.45
	100.00

Ann. de Chim. xxxi. 221.

7. *On the Transference of Fish from Salt Water to Fresh.*—A letter from Mr. Meynell, of Yarm, Yorkshire, has been read to the Wernerian Natural History Society, on changing the habits of fishes, and mentioning that he had, for four years past, kept the smelt, or spirling (*Salmo Eperlanus*), in a fresh-water pond, having no communication with the sea by means of the Tees or otherwise; and that the smelts had continued to thrive, and breed as freely as when they enjoy intercourse with the sea.—*Edin. Phil. Jour.* xiv. 354.

8. *Action of Poisons on Plants, by* M. Macaire.—The interesting memoir by M. Marcet, on the action of poisons on plants, with his conclusions, may be found abridged, vol. xx. p. 191, of this *Journal.* The experiments made by M. Macaire-Princip, and which he has published in a memoir on the influence of poisons on plants in which motion can be excited, are supplementary to those of M. Marcet; and we have been induced, by the interest they possess, to abridge them as follows.

The first plant used was the *berberris vulgaris.* The six stamina of the flowers of this plant have the property of rapidly approaching the pistil when touched by the point of an instrument: the motion occurs at the base of the stamens: when cold, the motion is sometimes retarded. When put into water or solution of gum, the flowers may be preserved many days, possessing their irritability. The petals and stamens close at night, to open again in the morning. The stem of this plant, put into dilute prussic

acid, for four hours, occasioned the loss of the contractile property by irritation; the articulation became flexible, and might be inclined in any direction by the instrument. The leaves had scarcely begun to fade. On placing the expanded flowers on the prussic acid, the same effect took place, but much more rapidly.

The experiment being repeated, with an aqueous solution of opium, a similar effect was produced in nine hours.

Dilute solutions of oxide of arsenic and arseniate of potash were used: the stamens lost the power of approaching the pistil; but they were stiff, hard, withdrawn backwards, and could not have their direction altered without fracture. It seemed like an irritation, or a vegetable inflammation.

Solution of corrosive sublimate more slowly produced the same effects.

Sensitive Plant (*Mimosa Pudica*). Experiments were now made with this vegetable. When a leaf of this plant is cut, and allowed to fall on to pure water, the leaflets generally contract rapidly; but after a few moments expand, and are then susceptible of contraction by the touch of any other body. They may thus be preserved in a sensible state two or three days. If the section be made with a very sharp instrument, and without concussion, the leaves may be separated without any contraction. The branches of this plant may be preserved for several days in fresh water. Gum-water also effects the same purpose.

When a cut leaf of this plant falls on to a solution of corrosive sublimate, the leaf rapidly contracts, and the leaflets curl up in an unusual manner, and do not again expand. When put into pure water, the sensibility does not return, but the whole remains stiff and immovable. A little solution of corrosive sublimate being put into a portion of pure water containing an expanded branch of the plant, gradually caused curling up of the leaves, which then closed and fell. If the solution be very weak, the leaves open on the morrow, and are still sensible, but ultimately contract, twist, and remain stiff till they die. Solutions of arsenic and arseniate of potash produce the same effects.

A leaf of the sensitive plant was placed in a cold diluted solution of opium. In a few moments it opened out as in water, and after half an hour gave the usual signs of contractilibity. In six hours it was expanded, and had a natural appearance, but could not be excited to move. The leaflets were flexible at the articulation, and offered a singular contrast to the state of irritation produced by corrosive sublimate. Pure water did not recover the plant. A large branch, similarly situated, expanded its leaves, but in half an hour had lost much of its sensibility: the leaflets, though alive, seemed asleep, and required much

stimulating to cause contraction. In one hour the contractions ceased; in two hours the branch was dead.

A leaf placed in prussic acid, (Scheeles strength,) contracted, then slightly dilated, but was quite insensible, and the articulations were flexible; water did not recover it. If the acid be very weak, the leaflets dilate, and appear to live well, but are insensible. A drop of the acid placed on two leaflets of a healthy plant, gradually cause contraction of the other leaflets, pair by pair. Solutions of opium and corrosive poisons have no effect when applied this way. After some time they dilate, but are insensible to external irritation; the sensibility returns in about half an hour, but the leaflets appear as if benumbed.

The plant exposed to the vapour of prussic acid is affected in the same way; ammonia appears to favour the recovery of the plant.

A cup containing dilute prussic acid was so placed, that one or two leaves, or sometimes a branch of a healthy plant, could be plunged into the liquid, or left to repose on its surface. The leaflets remained fresh and extended, but were almost immediately insensible. Being left in this state for two hours, they were expanded, and no irritation could cause their contraction, though otherwise there was no appearance of an unnatural state. At five o'clock in the evening the leaves were left to themselves. At nine o'clock they were open and insensible. At midnight they were still open, whilst all the rest of the plant, and the neighbouring plants, were depressed, contracted, and in the state of sleep. On the morrow they resumed a little sensibility, but seemed benumbed.

In the same manner M. Macaire has interfered with other plants, as to the state of sleep, and observes that prussic acid thoroughly deranges the botanical indications of time of Linnæus.

We may then, without altering the life of a sensitive plant, act directly on the organ, whatever it may be by which it is enabled to accomplish these singular movements; and may we not infer, without being accused of bold suppositions, that these movements are not entirely dependant on those forces which preside over the nutrition of the vegetable.—*Bib. Univ.* xxxi. 244.

9. *Boletus Igniarius.*—An individual plant, of *boletus igniarius* was remarkable for its enormous size, and the fleshy nature of its substance. After a large circular incision had been made in it, the two edges were united by the first intention, and were readily consolidated. Still farther, a portion of the fungus cut off, and left on the ground for two days, was applied to a newly-cut portion of the boletus. The union took place as well as in the former case; and the separated part could only be known by the cicatrix.—*Amer. Journal*, &c.

10. *New Mineral—the Gay-Lussite.*—This mineral was found by M. Boussingault in great abundance, at Lagunilla, a small Indian village, about a day's march to the south-west of the town of Merida. It is at this place that the carbonate of soda, called *urao*, is excavated; but before arriving at that substance they pass through a bed of clay, containing a multitude of crystals, which, at first, were mistaken for carbonate of lime, and were, from their forms, called *clavos* (nails). These crystals are transparent and colourless, or sometimes grayish and semi-transparent, surface dull; they cause double refraction; they scratch gypsum, but are scratched by carbonate of lime; are brittle, yield a conchoidal or irregular vitreous fracture. The crystals are very imperfect in form, and have a specific gravity of 1.928. 1.95. By heat they decrepitate, become opaque, and yield much water: before the blowpipe it suddenly fuses into a globule, which instantly becomes infusible, and is then alkaline on the tongue. It dissolves in small quantity in water, yielding a solution reddening turmeric paper, and precipitated by oxalic acid. After being heated, the action of water is simply to dissolve out carbonate of soda, and leave carbonate of lime. Being analyzed, it was found to contain very little else than these two substances with water. It yielded, per cent.

Carbonic acid	28.66	or	Carb. soda	33.96
Soda	20.44	—	Carb. lime	31.39
Lime	17.70	—	Water	32.22
Alumine	01.00	—	Carbonic acid	01.45
Water	32.20	—	Alumine	01.00
	100.00			100.00

Hence it may be considered as composed of 1 atom carbonate of soda, 1 atom carbonate of lime, and 11 atoms of water: or, as crystallized carbonate of soda contains 11 atoms of water, it may be considered as containing 1 atom carbonate of lime, and 1 atom crystallized carbonate of soda.—*MM. Boussingault and Cordier.*—*Ann. de Chim.* xxxi. 270.

11. *Pholerite, or Silicate of Alumina*—Found in the coal formation of Fins, (Allier,) filling fissures in the ironstone, and accompanying schists. It frequently occurs, but never in large portions. It has a pure white colour, exists as small convex nacreous scales, soft and friable, and feeling adhesive to the tongue. When heated it yields water, and consists per cent. of

Silica 41.775 Alumina 43.104 Water 15.121.

—*Annales des Mines*, xi. 489.

12. *On the presence of Iodine in Mineral Waters*—Extract of a letter from M. Liebeg to M. Gay-Lussac. "I have lately been

occupied in the analysis of the mineral waters of our country, (Darmstadt,) and I find that all these waters contain hydriodic acid in larger or smaller quantity. It is by the use of aqua regia, diluted with sixty times its weight of water, and by starch, that I have succeeded in discovering the smallest trace of this body in the mother-waters of these waters.

"The saline water of Kreutznach (Theodorshalle) is remarkable for the large quantity of hydriodic acid, or iodine, which it contains; besides this body the muriates of lime and magnesia are present. I mixed six pounds of the mother-water of this water with sulphate of soda, and after having separated the sulphate of lime, I evaporated the liquor until the greatest part of the common salt was crystallized. The dark brown liquid which remained, distilled with its weight of sulphuric acid, gave 0.253 grammes (3.9 grains) of iodine."—*Ann. des Chim.* xxxi. 355.

13. *Sound attending the Aurora Borealis.*—Speaking of this phenomenon, M. Ramm states—" I believe that I have heard it repeatedly during a space of several hours, when a boy of ten or eleven years old, (it was in the year 1766, 1767, or 1768.) I was then crossing a meadow, near which was no forest, in winter, and saw, for the first time, the sky over me glowing with the most brilliant light, playing in beautiful colours, in a manner I have never seen since. The colours shewed themselves very distinctly on the plain, which was covered with snow or hoar frost, and I heard several times a quick whispering sound simultaneously with the rays over my head. However clear this event is, and always has been in my memory, it would be unjust to expect it to be received as an apodictical truth; but should others have made similar observations, it would be important for the inquirer into the nature of the aurora borealis.—Ramsmoem in Törset, March, 1825.—*Phil. Mag.* lxvii. 177.

Art. XX.—METEOROLOGICAL DIARY for the Months of March, April, May, 1826, kept at Earl Spencer's Seat at Althorp, in Northamptonshire.

The Thermometer hangs in a North-eastern Aspect, about five feet from the ground, and a foot from the wall.

For March, 1826.

	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Wednesday - 1	39	53	29.86	29.70	WSW	SW
Thursday - - 2	43	52	29.54	29.54	WbS	W
Friday - - - - 3	42	49	29.50	29.50	W	WbN
Saturday - - 4	34	52	29.50	29.50	SE	WSW
Sunday - - - 5	32	47	29.62	29.80	WSW	WbS
Monday - - - 6	28	47	29.97	29.68	SW	ESE
Tuesday - - - 7	40	54	29.62	29.62	S	SW
Wednesday - 8	40	54	29.85	29.85	W	SE
Thursday - - 9	41	62	29.88	30.00	SE	SE
Friday - - - 10	43	62	30.10	30.17	SE	SE
Saturday - - 11	38	50	30.17	30.17	E	E
Sunday - - - 12	29	49	30.30	30.30	NE	E
Monday - - - 13	30	46	30.30	30.21	E	E
Tuesday - - - 14	32	48	29.90	29.80	E	SW
Wednesday - 15	33	47	29.75	29.77	W	E
Thursday - - 16	29	44	29.96	30.15	N	NE
Friday - - - - 17	25	42	30.22	30.20	NE	SbW
Saturday - - 18	22	44	30.14	29.89	SW	WbS
Sunday - - - 19	35 5	47	29.78	29.86	NW	N
Monday - - - 20	33	48	29.86	29.90	WbN	NNE
Tuesday - - - 21	34	46	29.90	29.90	N	NNE
Wednesday . 22	36	44	29.80	29.72	NNE	NNE
Thursday - - 23	32	43	29.63	29.38	NbW	N
Friday - - 24	32	40	29.40	29.60	E	NE
Saturday - 25	33	41	29.67	29.67	NE	NE
Sunday - - - 26	32	39.5	29.69	29.80	NE	NNE
Monday - - - 27	26	42	29.83	29.83	N	NbW
Tuesday - - - 28	31	52	29.73	29.60	W	SW
Wednesday - 29	43	46	29.47	29.60	W	NW
Thursday - - 30	27	46	29.80	30.08	WbN	WNW
Friday - - - - 31	27	47	30.17	30.20	WbN	W

For April, 1826.

	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Saturday - - 1	25	52	30.20	30.11	WbN	WSW
Sunday - - - 2	42	54	29.97	29.97	W	W
Monday - - - 3	49	60	30.00	30.08	W	W
Tuesday - - - 4	44	58	30.08	30.01	W	W
Wednesday - 5	46	56	29.95	29.95	W	W
Thursday - - 6	45	60	29.95	29.94	W	W
Friday - - - - 7	49	63.5	29.90	30.00	W	WbS
Saturday - - 8	43	59	30.00	29.90	WbS	SW
Sunday - - . 9	48	63	29.64	29.60	SW	SW
Monday - - , 10	39	55	29.70	29.77	W	SW
Tuesday - - - 11	45	61	29.68	29.58	SW	W
Wednesday - 12	46	54	29.07	29.39	WbS	NW
Thursday - - 13	41	56	29.88	29.98	NW	W
Friday - - - - 14	43	64	30.07	30.07	W	W
Saturday - - 15	46	64.5	30.07	30.07	W	W
Sunday - - - 16	47	55	30.02	30.10	WNW	WNW
Monday - - 17	34	54	30.15	30.15	WbN	NW
Tuesday - - - 18	31	57	30.13	30.04	NW	SW
Wednesday - 19	36	60	29.98	29.90	SW	S
Thursday - - 20	28.5	60	29.80	29.62	S	SE
Friday - - - 21	34	62	29.53	29.53	S	SSE
Saturday - - 22	42	66	29.50	29.54	SE	WNW
Sunday - - - 23	42	52	29.65	29.65	NW	WbN
Monday - - - 24	29	52	29.70	29.77	NW	NW
Tuesday - - - 25	30	55	29.85	29.80	NW	W
Wednesday - 26	39	52	29.60	29.59	NW	NW
Thursday - - 27	37	49	29.40	29.45	NW	NE
Friday - - - - 28	29.5	44	29.74	29.80	NW	NNW
Saturday - - 29	29	48	29.84	29.90	NW	NW
Sunday - - - 30	26	52	30.00	30.05	N	N

For May, 1826.

	Thermometer.		Barometer.		Wind.	
	Low	High	Morn.	Eve.	Morn.	Eve.
Monday - - - 1	29	54	30.10	30.10	NNE	NE
Tuesday - - - 2	27	55	30.05	29.90	NE	NW
Wednesday - 3	45	29	29.90	29.95	NE	NE
Thursday - - 4	37	48	29.95	29.95	NW	NE
Friday - - - - 5	37	53	29.95	29.98	NNE	NE
Saturday - - 6	34	49	29.98	29.92	N	NE
Sunday - - - 7	36	52	29.92	29.96	NE	NE
Monday - - - 8	42	54	29.98	29.97	NE	NE
Tuesday - - - 9	32	58	29.97	29.91	NE	ENE
Wednesday - 10	39	60	29.91	29.91	E	NE
Thursday - - 11	45	63	29.91	29.98	NE	NE
Friday - - - - 12	39	54	30.10	30.10	NE	NE
Saturday - - 13	29	56	30.14	30.08	NE	EbN
Sunday - - - 14	34	61	30.01	29.98	E	E
Monday - - - 15	31	60	29.98	30.00	E	ENE
Tuesday - - 16	35	67	30.00	29.96	NE	NW
Wednesday - 17	42	66	29.96	29.96	NW	NW
Thursday - - 18	49	73	29.98	29.92	NW	W
Friday - - - - 19	42	72	29.81	29.65	W	SE
Saturday - - 20	48	63	29.60	29.76	E	NE
Sunday - - - 21	36.5	65	29.90	29.93	NNE	NNE
Monday . - - 22	45	70	29.97	29.95	N	ENE
Tuesday - - 23	46	67	29.95	29.80	NE	NE
Wednesday - 24	45	65	29.78	29.73	NE	NE
Thursday - - 25	50	67	29.69	29.60	NNE	NbW
Friday - - - 26	51	64	29.58	29.60	NE	NE
Saturday - - 27	47	65.5	29.70	29.70	EbS	NE
Sunday - - - 28	50	62	29.80	29.73	NE	NE
Monday - - - 29	49	57	29.70	29.73	EbN	NE
Tuesday - - - 30	49	53	29.77	29.77	NE	NE
Wednesday - 31	48	58	29.80	29.80	NE	NE

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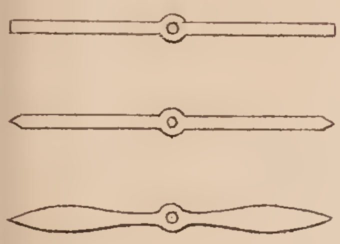
Fig. 20.

Fig. 21.



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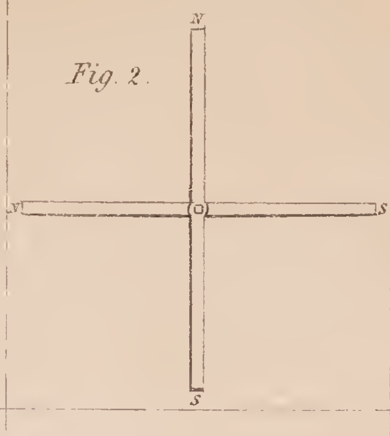

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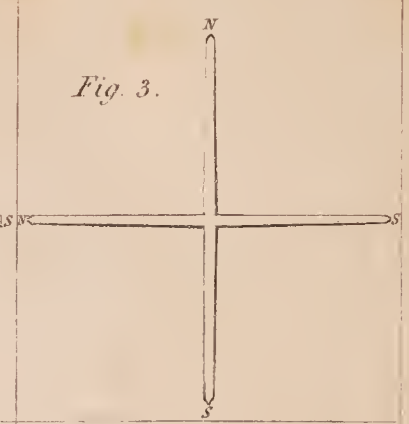

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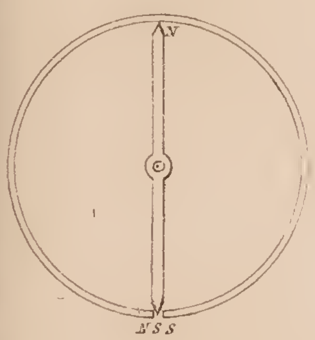

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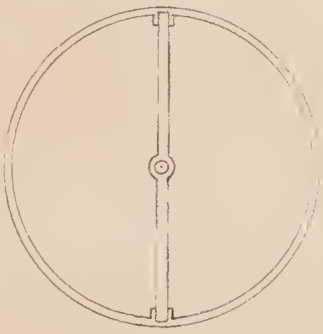

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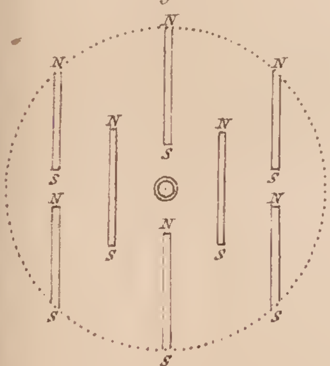

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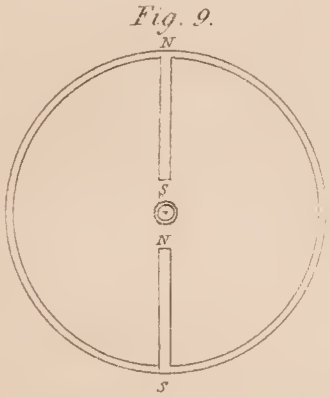

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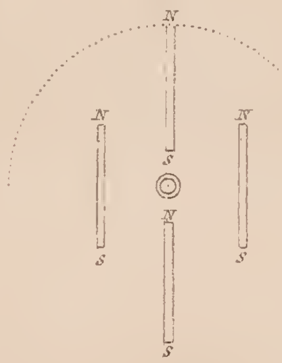

Fig. 11.

Fig. 12.

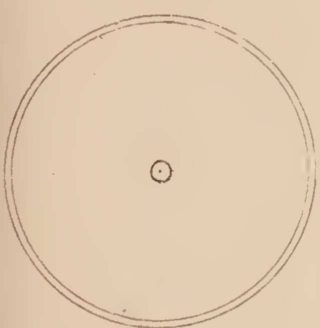

Fig. 13.

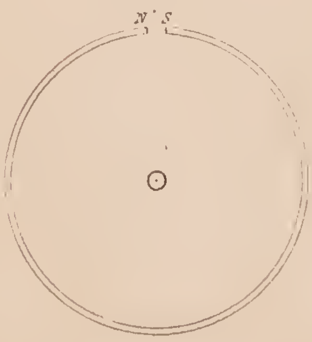

Fig. 14.

Fig. 15.

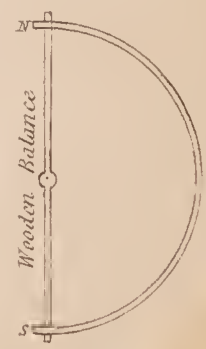

Fig. 16.

Fig. 17.

Fig. 18.

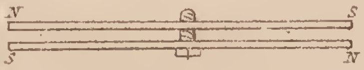

Fig. 19.

London; May 30, 1826.

THE
London Medical and Physical Journal,

EDITED BY DR. MACLEOD.

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